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FOREST HEALTH

IN WEST COAST FORESTS

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Forest Health in West Coast Forests 1997 - 1999

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ABSTRACT

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This report examines some forest health issues current in West Coast states in 1997, 1998 and 1999. The narrative discusses forest ecosystem disturbance, two significant forest insect and disease problems — Swiss needle cast and spruce beetle — forest fragmentation and urbanization, and introduction of exotic organisms. The Forest Health Monitoring (FHM) program is briefly described, and aerial survey and FHM plot data are presented in the appendices.

Key Words

Disturbance, exotic plants, forest fragmentation, forest health, forest insects, monitoring, spruce beetle, Swiss needle cast, tree diseases, urbanization.

This is a publication of the USDA Forest Service, Forest Health Monitoring Program, in cooperation with the states of Oregon, Washington, Alaska, California and Hawaii.

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INTRODUCTION

Forest Health Monitoring (FHM, Appendix A) is a national program designed to annually determine the status, changes and trends in indicators of forest conditions. The FHM program uses data from a grid of ground plots (Appendices A and B), other ground surveys, aerial (Appendix C) and satellite surveys, and other biotic and abiotic data sources, and develops analytical approaches to address issues that affect the sustainability of forest ecosystems (USDA Forest Service 1997).

The FHM program on the West Coast began in California in 1992, and in Oregon and Washington in 1997. Alaska and Hawaii will enter the program within two years. As part of the program, a variety of reports are being issued annually or periodically as sampling cycles are completed.

This report is the first in a series of publications that will emphasize current issues. The following are addressed in this publication:

- Forest disturbance;
- Native insects and diseases;
- Forest fragmentation and urbanization;
- Introduction of exotic plants, insects and disease organisms.

Subsequent reports will address such topics as climate- and weather-related events, or will return to previous topics as warranted by data analysis or on-the-ground developments.

All reports will contain core tables of data obtained from sampling the FHM grid of plots (Appendix B). As indicators such as ozone damage and soils are included in the program, additional tables for these indicators will be added. As trends are observed from data analysis, the plot data will be used more extensively in issue discussions. Trends will be more extensively addressed in larger reports published every four or five years.

Disturbance to the forested landscape will be a common thread through all of the reports. Issues addressed in this and future reports are the result of disturbances. If changes to forests remain within the historic range of variation, there is a high probability that the forested ecosystem is sustainable. If not, change is taking place that may result in unsustainable ecosystems.

Definition of Forest Health

A healthy forest can renew itself vigorously across the landscape, recover from a wide range of disturbances, and retain its ecological resilience while meeting current and future needs of people for values, uses, products and services.

Adapted from: *Forest Health Policy,* USDA Forest Service, 1997

DISTURBANCES

To most people, forests appear unchanging. This perception is due to the relatively short time we are around to observe forests; even "short-lived" trees live longer than humans (Fig. 1). Actually, most forests are in some stage of re-establishment after one or more disturbances. In the West, forests have been shaped by geological processes, climatic forces, fire, insects and disease, and animal and human activity. To monitor and evaluate forest health, we must understand how these cycles of disturbances influence various forest ecosystems.

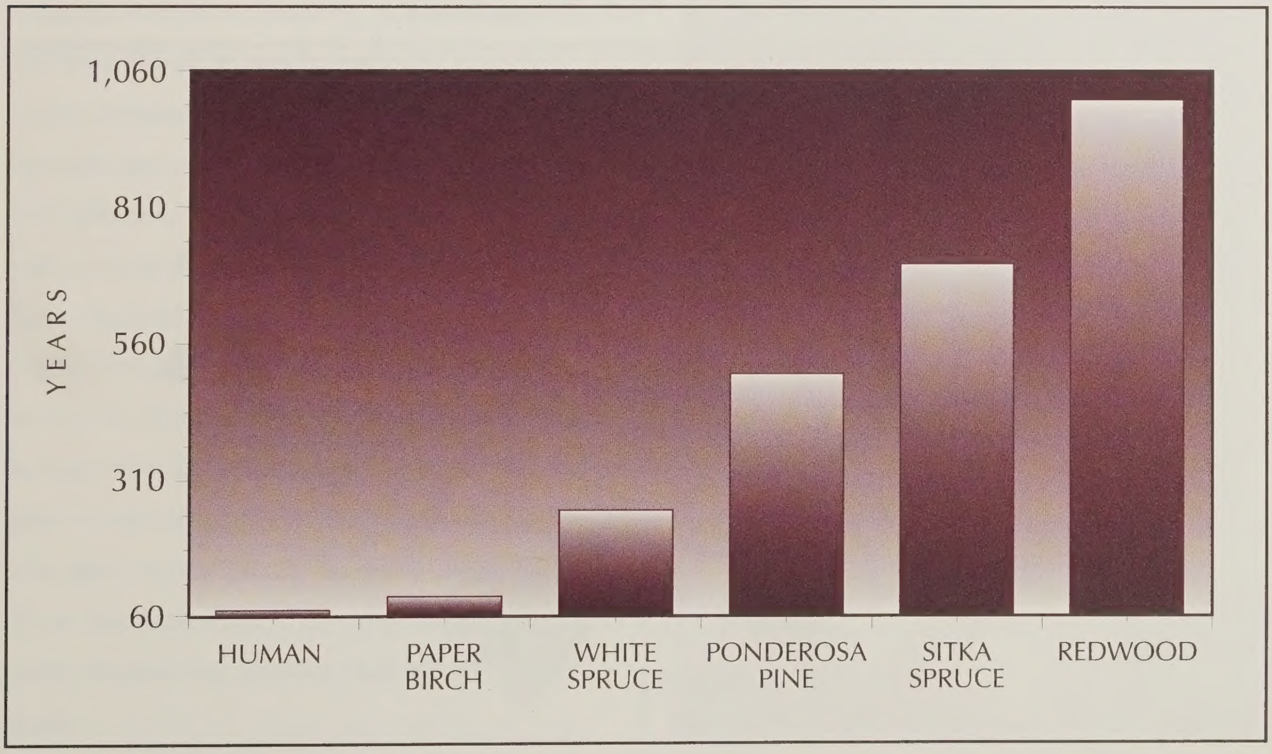
Geological Processes

Volcanoes and earthquakes are geological events that occur wherever there is active movement of the earth's crust. While these major events usually are of short duration and can destroy existing vegetation over large areas, their influence on the landscape is long-lasting due to heavy deposits of lava or ash, and changes in land elevations and water tables.

Climatic Forces

Atmospheric and oceanic currents influence climate on a global scale. There is evidence that long-term global climate patterns have undergone rapid shifts. Regional conditions and local topography strongly affect shorter climate cycles. These cycles, in turn, can trigger many types of disturbances, including wind or storm events, droughts and floods, avalanches and landslides. Temperature and

Figure 1. Human Life Span Compared with Common Trees of the Pacific Coast



moisture levels also affect insects and plant disease organisms and their hosts. Long-term climate shifts also influence site suitability. A species may die out in an area if conditions become less favorable, or invade new areas if conditions become more favorable.

Wind is an important disturbance factor in coastal rainforests where large-scale disturbance is relatively rare and the tree species are long-lived. Intensity and frequency of wind events are related to exposure, landscape position and topography.

Drought is the most common climate-related disturbance in California. Wide fluctuation in precipitation is normal, but when winter rains are 80 percent or less than average, conifer mortality is often high because of increased susceptibility to insects and pathogens. Drought damage is more intense in wetter habitats than in arid areas because the plants have fewer adaptations to drought conditions.

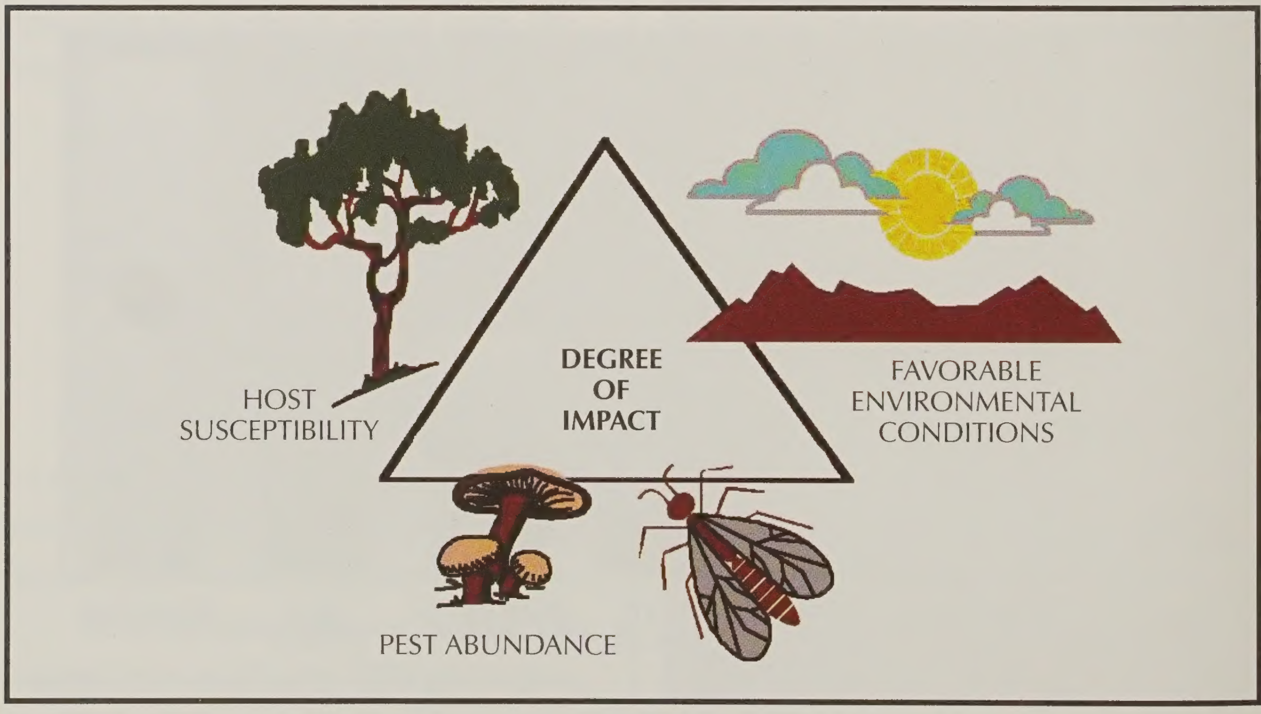
Fire

Fire is important in forests in California, southwest Oregon, east of the Cascade Mountains in Oregon and Washington, and the boreal regions of Alaska. The climate and topography in these areas provide lightning for ignition, dry periods that result in dry fuel, vegetation that is vulnerable to ignition, and wind to drive flames. Recovery time after fire depends on the frequency and intensity of the fire. Generally, forests with frequent, low-intensity fire regimes recover quickly. Where fires are less frequent, they tend to be more intense, effectively removing much more vegetation. These types of fires are followed by a much longer recovery period.

Insects & Diseases

Insects and plant diseases, the traditional focus of forest health assessments, are integral components of forest ecosystem function. They play a critical role in nutrient recycling and

Figure 2. Pest Outbreak Triangle: Host Susceptibility, Favorable Environmental Conditions & Pest Abundance



small-scale disturbance. The size and severity of insect or disease outbreaks are influenced by the biology of the insect or pathogen, the availability of susceptible host material, and environmental conditions (Fig. 2). Most forest insects and pathogens are host specific and directly affect one to a few tree species within a community. Exotic insects, diseases and plants have the potential to affect forest ecosystem function when they become established in areas where they have no competitors or they out-compete the native species in the absence of natural control organisms. Areas where there is abundant trading and shipping, and/or large influxes of people, are most prone to invasions by exotic species. On the West Coast, Hawaiian and Southern Californian forests have shown the greatest number of introductions.

Humans

Human influence, past and present, is apparent on our forests. Harvesting trees often changes forest composition and structure, while urban development, farming and ranching convert forestlands to non-forestlands. By effectively suppressing fire in the past half century, humans have influenced fire-dependent forests in California, Oregon and Washington. As a result, species composition and stand structures have changed, leaving the forests more prone to higher intensity fires, and insect and disease outbreaks. Excessive ozone from industry and automobiles damages some forest species, and alters forest composition and structure. People also have moved plants, animals, insects and plant diseases from place to place, inadvertently introducing exotics that are potential pests.

Summary

Disturbances result in changes to ecosystem function. In forests, this often means the sudden death or removal of trees. Other disturbances can be slow, as a result of gradual changes in environmental conditions. Disturbance and recovery cycles repeat over time and across landscapes. From evidence of past disturbances on a landscape, we can predict what type of disturbance is likely to occur in the future. Advances in science and technology have enabled us to look at time spans much longer than our own lifetime, but we are still discovering the complexity of factors involved with climate change and geological processes. Understanding the physical and ecological factors influencing the disturbance regimes of the forests we manage is essential.

Fire is a common agent of disturbance and change in many forested ecosystems in the West. Photo courtesy of Oregon Department of Forestry.

NATIVE INSECTS & DISEASES

Native insects and diseases are a natural part of forested ecosystems, and the severity of their impacts is cyclic. In many areas, normal cycles of insect and disease epidemics have been altered by human influences so that the intensity, frequency or geographical scope of outbreaks or infections are frequently greater than before. In the West, fire suppression and harvest practices have changed the species composition and structure of many forests, making them more susceptible to insects and diseases. Two examples of native insects and diseases that are currently causing widespread mortality or unprecedented defoliation and growth loss are described below.

Spruce Beetle in Alaska

The first recorded spruce beetle outbreak in Alaska was in the 1920s. From that time to the late 1970s, outbreaks averaged less than 100,000 acres per year. Infested acreage doubled or tripled over the next 20 years when, in 1996, it reached an all-time high (Fig. 3) of more than 1 million acres (Wittwer 1998).

The reasons for the increase in beetle activity are not fully understood, but may be related to increases in temperatures throughout south-central and interior Alaska over the past 100 years. Temperature increases have either increased host susceptibility or benefitted spruce beetle populations by shortening their life cycles, thereby increasing the number of favorable dispersal periods. Greater beetle activity also may be the result of more spruce reaching physiological maturity in the last 100 years because spruce trees become more susceptible to spruce beetle with age.

Over the past 10 years, spruce beetle has affected 2 million to 3 million acres of forested land in Alaska. In many areas, 80 to 90 percent of the susceptible spruce has been killed, leaving few or no living susceptible trees to support further beetle activity.

Spruce beetle activity has declined over the past several years, from a peak of 1.1 million acres in 1996 to 253,000 affected acres in 1999. (This is the lowest acreage since 1990.) Lack of suitable host material within susceptible stands of mature, even-aged, slow-growing spruce may account for this continued decline. Activity does vary, however. Beetle populations remain active in areas such as the west shore of Cook Inlet; some areas, such as the Kenai

Spruce mortality caused by the spruce beetle has increased the risk of catastrophic wildfire, changed wildlife habitats, degraded aesthetic quality and reduced property values. Photo courtesy of Roger Burnside.

Mortality of spruce from an outbreak of the spruce beetle has significantly changed the character of the forests of the southern Kenai Peninsula over the past five years. Photo courtesy of Roger Burnside.

Peninsula from Ninilckik south to Homer, have actually experienced a slight increase.

Damage caused by spruce beetle has ecological and socio-economic consequences. When a significant portion of the spruce-forest overstory is killed, understory ground vegetation increases and can delay or prevent the establishment of seedlings. This can cause long-term stand conversions, changes in wildlife habitat quality and stream flows. Dead trees lose merchantable value within three years and contribute to fuel loading, increasing wildfire hazard. Greater fire hazards raise private-property liability and human-safety issues.

Swiss Needle Cast

Since the early 1980s, thousands of acres of Douglas-fir plantations along the Pacific

Figure 3. Spruce Beetle Infestation in Alaska, 1974 - 1999

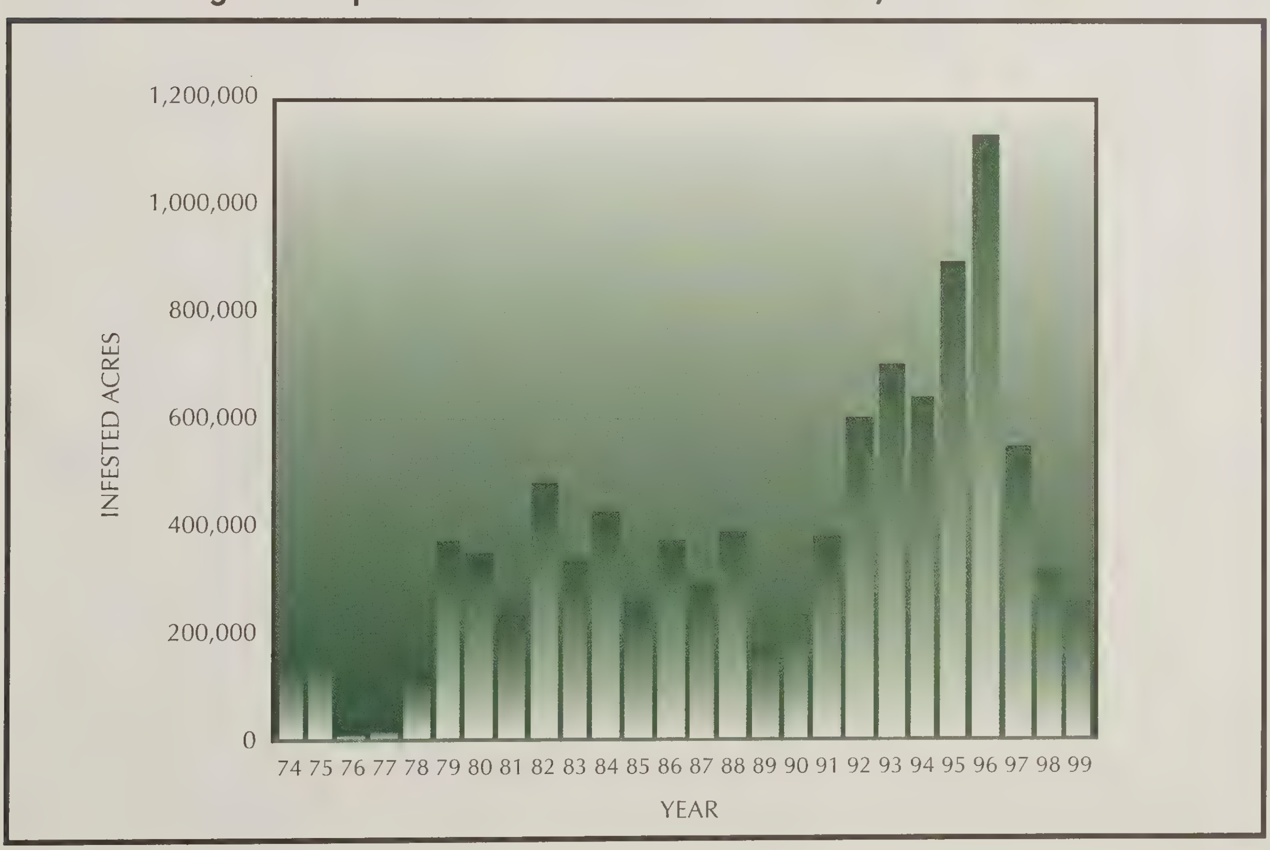
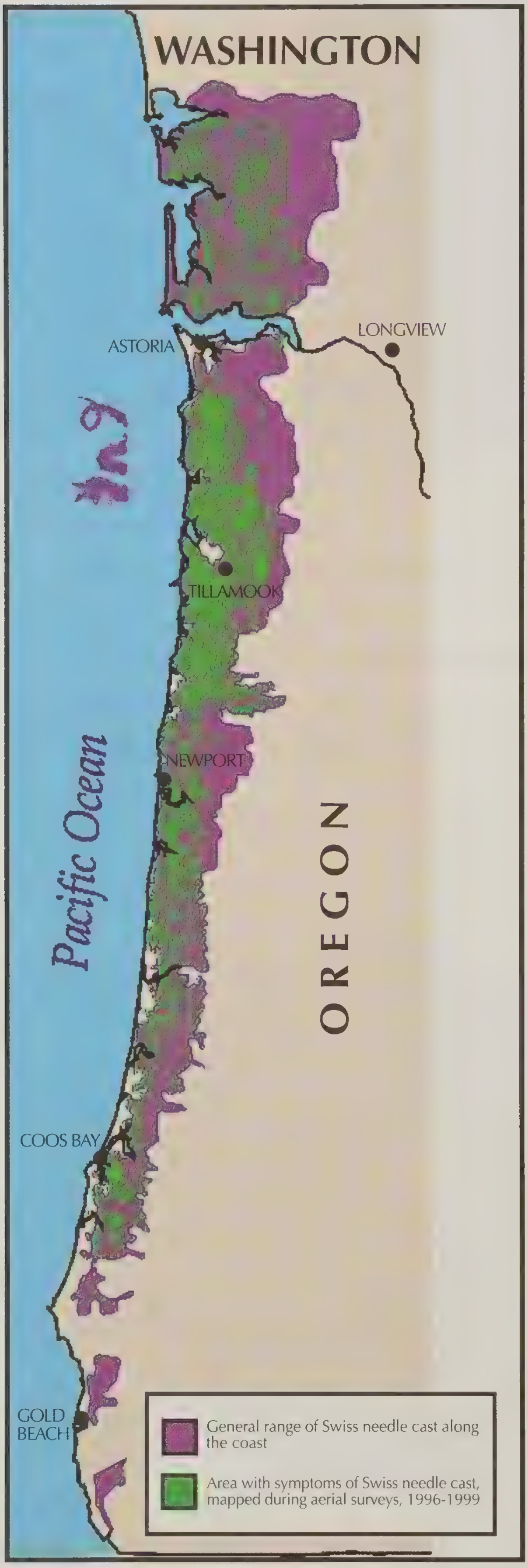


Figure 4. Swiss Needle Cast in Oregon & Washington, 1996 - 1999



The yellowish tint of a young Douglas-fir plantation in western Oregon is a symptom of serious damage caused by the Swiss needle cast fungus. Photo courtesy of Alan Kanaskie.

Coast, from southern Washington to southern Oregon, have shown increasingly severe damage from Swiss needle cast. Most of the damage is concentrated along the northern Oregon coast. Springtime aerial surveys to map the extent and severity of damage (Fig. 4) started in 1996 in Oregon and 1998 in Washington.

In Oregon, the mapped area with symptoms of Swiss needle cast has increased from 130,000 acres in 1996 to 295,000 acres in 1999 (Kanaskie and McWilliams 1999). In Washington, mapped acres with Swiss needle cast symptoms have increased from 44,500 acres in 1998 to 200,000 acres in 1999 (Omdal and Moore 1999). Mapped acreages are conservative because they represent only those areas with obvious symptoms at the time that aerial surveys are conducted, usually in April.

The reasons for increasingly severe damage in coastal forests over the past 10 to 20 years is unclear. The conversion of large expanses of coastal hemlock and spruce forests to Douglas-fir plantations, increasing spore loads,

nonlocal Douglas-fir seed sources and weather conditions are possible factors that have influenced disease severity (Oregon Department of Forestry 1998).

The loss of tree growth in stands with Swiss needle cast has great economic and ecological consequences to landowners and public land managers. Decisions about the future management of these lands, whether for timber production or other values, are being influenced by the disease's presence and impact.

Defoliation caused by the Swiss needle cast fungus results in thin foliage and reduced tree growth and vigor. Photo courtesy of Alan Kanaskie.

Swiss needle cast up close

The soot-like streaks on the undersurface of the Douglas-fir needles are the fruiting bodies of the fungus. Photo courtesy of Alan Kanaskie.

Swiss needle cast disease is caused by a fungus, *Phaeocrytopus gaumanii.* The fungus infects the needles, impairing the tree's ability to regulate water loss and causing premature loss of needles. Severely damaged trees grow poorly and may die. Most stands with severe symptoms are within 20 miles of the coast in the fog zone. Much of this area was previously dominated by hemlock, spruce or western redcedar.

FOREST FRAGMENTATION & URBANIZATION

Direct human activities are a form of disturbance that currently have a major effect on the amount and continuity of forestland.

Forest Conversion

Typical forest conversions include changes to agriculture and urban uses, flooding caused by dams and reservoirs, road construction, and establishing powerline rights-of-way. It is generally desirable that the forestland base not be diminished over time, unless a higher societal benefit is achieved by such conversion.

The relative value of forest and alternative land uses changes greatly over time. For example, although the creation of reservoirs accounted for the loss of 15,000 acres of nonfederal timberland in western Oregon between 1961 and 1985, no additional forestland was converted to reservoirs between 1985 and 1994 (McKay et al. 1998). In fact, the removal of two dams and their reservoirs on the Elwha River in Washington is now being contemplated to restore salmon habitat.

Privately owned forestland is generally viewed as most vulnerable to conversion because such land is often located closer to human population centers and because there are often few binding policy or legislative restrictions on its development. There is disagreement between societal efforts to determine the highest or best long-term use of land versus revoking current

Definition of Forestland

Forestland is at least 10 percent stocked with tree or woodland species, or currently non-stocked but once had such stock, and not developed for use other than growing trees (orchards and Christmas tree plantations do not qualify). To qualify as forest, the site must be attached to forest and that is at least one acre in area and at least 120 feet wide. Wooded areas less than 120 feet wide are considered forest if attached to forestland that meets the minimum size requirements if they are within 120 feet of the larger body. Lands with forested campgrounds and improved roads are classified as "urban" even if they are surrounded by forest.

— *Forest Health Monitoring Field Methods Guide*, 1999

development restrictions on the rights of private individuals to use their land as they wish.

Forest Fragmentation

The amount and variability of forest cover affects its resilience and ecological function. Parcel size also affects the continuity and complexity of management efforts applied to projects across landscapes. A large, uniform continuous forest may provide expansive areas of high-quality wildlife habitat or watershed protection, a huge reservoir of valuable forest products, or an area susceptible to widespread outbreaks of insects or disease.

When forests are fragmented, the resulting diversity of habitats and age cohorts can be beneficial. Forest resources, structures and products can be continuously produced and rejuvenated over time. People have access to a variety of desirable settings for recreation. Certain wildlife species thrive along edges and in places with diverse forest structure.

However, increased fragmentation may also degrade the types, quality and connection of wildlife habitats, increase the vulnerability of certain species to predation or disease, and extend the access of generalist species into previously isolated areas. When urban or suburban areas extend into forests, desirable home sites become available. However, forest cover is depleted and people may be exposed to hazardous trees and wildfires, and management options on adjacent lands may be reduced.

The effects of forest fragmentation depend on the characteristics of the resulting dissimilar patches, and their size and number across the landscape.

Current Information

As human populations in the western states grow (Table 1), forests will likely be converted to nonforest uses; remaining forested patches are likely to become more fragmented. A recent study of aerial photographs taken in Washington's Puget Sound region revealed a 3-percent decrease (195,000 acres) in primary forestland between 1979 and 1989 (MacLean et al. 1997).

In contrast, a report from western Oregon (McKay et al. 1998) shows that from 1984 to 1994, nonfederal forested land decreased 77,000 acres due to roads, agriculture and urban expansion. However, afforestation of 109,000 acres of farms, pastures and Christmas tree plantations actually caused a net increase of 32,000 acres in forest.

Cultural, political, and current and future economic incentives contribute to the balance between forest conversion, utilization and restoration. Global wood and pulp markets, housing demands, local growth-management restrictions, forest practice laws and endangered species protection regulations affect forestland management trends. Policies and incentives to protect or restore forestland for tax relief or personal altruism are important. For example, it is a worthwhile social and ecological goal to protect or restore forestland closest to streams, rivers and other waterways to prevent pollutants and sediments from entering waterways, to improve fish and wildlife habitat, and reduce flooding. Such policies are not well-conceived, however, if they result in increased destructive practices on other forestland which is unregulated.

Table 1. Anticipated Population Growth in the West Coast Region

Population numbers are in thousands

STATE	CURRENT POPULATION		PROJECTED POPULATION			
	1997	RANK	2015	RANK	2025	RANK
ALASKA	609	48	791	47	885	45
CALIFORNIA	32,268	1	41,373	1	49,285	1
HAWAII	1,187	41	1,553	40	1,812	39
OREGON	3,243	29	3,992	27	4,349	26
WASHINGTON	5,610	15	7,058	13	7,808	13

Source: www.census.gov/population/projections

Table 2. Condition Classes Across California, Oregon & Washington as Estimated by Forest Health Monitoring Plot Classifications

(only forested plots are measured)

LAND USE	CALIFORNIA 610 PLOTS (percent)	OREGON 411 PLOTS (percent)	WASHINGTON 288 PLOTS (percent)
FOREST	31.2	47.4	58.5
AGRICULTURE	24.0	38.4	31.3
RANGE	18.4	11.5	6.2
URBAN	2.3	2.1	3.4
WATER	2.1*	0.5	0.5
ROCKY, BARREN	21.9	—	—

* Includes marsh

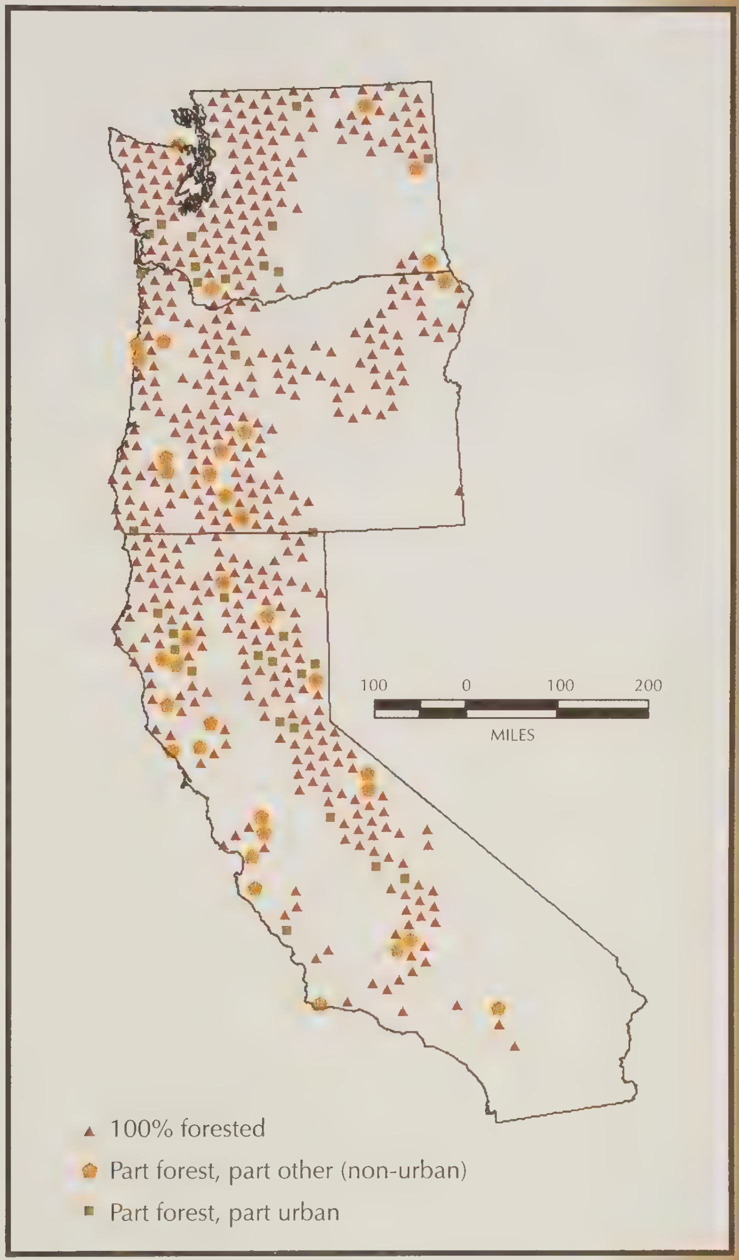
Forest Health Monitoring

The Forest Health Monitoring Program measures changes in forestland base and fragmentation over time through recording "condition classes" on sampled plots (Fig. 5). Although forest conditions have to be present on at least a portion of the plot for any measurements to be taken, contrasting land-use conditions such as urban, pasture, cropland and other nonforested conditions are recorded. Some of those nonforest conditions can naturally return to forest in time or be quickly converted by planting; forested lands can be converted to nonforest uses as well.

Table 2 shows the distribution of condition classes across all Forest Health Monitoring plots for Oregon, Washington and California. Only forested plots are measured.

The 1996 National Technical Report on Forest Health (Stolte 1997) reported that California has large areas with plots that are completely forested. Parts of Northern California have a relatively large number of plots with both forest and urban land-use conditions. The changes from forest to nonforestland over time will help quantify rates of forestland conversion and fragmentation in the future. Trend data also can indicate the location of the most rapid changes or those ecosystems that are most at risk from changes.

Figure 5. Forested or Partially Forested FHM Plots in California, Oregon & Washington



EXOTIC PLANTS, INSECTS & DISEASES

Over the past century, West Coast states have experienced increased exposure to exotic (non-native) plants, insects and diseases. The vast majority of these newcomers are unable to establish viable, reproducing populations in their new home. However, small subsets have not only established themselves but have actually outcompeted native species. For example, in Hawaii more than 4,600 different plants have been introduced, and 86 (less than 2 percent) have become serious pests (Smith 1985). Since native flora and fauna did not evolve in the presence of these new competitors, native populations are often overwhelmed, thus reducing biodiversity.

Hawaii, like most tropical islands, has proven to be inordinately vulnerable to invasions by exotic plants, insects and diseases (Loope and Mueller-Dombois 1989). Today, only remnant populations of uninvaded flora exist in Hawaii, and many species of flora and fauna have become extinct. The primary invasive plants presently affecting Hawaii's forests are miconia and banana poka; the most devastating exotic insect is the two-spotted leaf hopper (personal communication, Victor Tanimoto, Hawaii Division of Forestry and Wildlife).

California's forested landscape also has been dramatically changed by the presence of exotics. In addition to the many exotic and invasive weeds, introduced diseases, such as white pine blister rust on five-needle pines and pitch canker on Monterey and Bishop pines, are gradually changing the distribution and abundance of some of California's native pines. Fortunately, the Alaskan forests are relatively unaffected by exotics. In Oregon and Washington, Port-Orford-cedar root disease, white pine blister rust and the balsam woolly adelgid have been present and active since their introduction 50 to 80 years ago. The ever-present threat of insects such as the gypsy moth or Asian long-horned beetle, and the spread of plants such as yellow starthistle and English holly, continues to keep land managers wary of what may lie ahead.

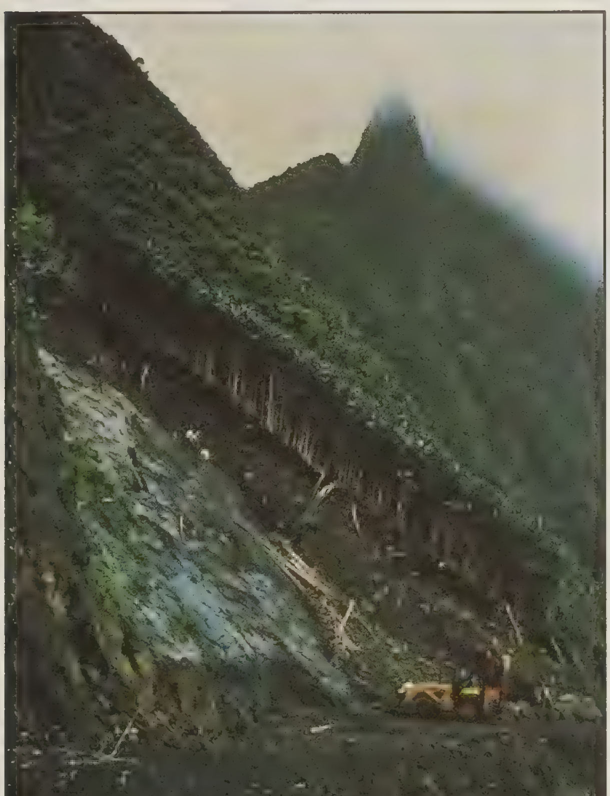
Exotic Plants

Exotic plants that become "noxious weeds" directly compete with the native flora for light, water, nutrients and space. These plants have a common set of characteristics that allow them to successfully displace their native counterparts: a high reproductive potential and growth rate, efficient nutrient uptake at low nutrient levels, efficient seed vectors and low mortality. They also enhance their populations by disrupting natural processes, thus favoring their own more competitive behavior (Rutherford et al. 1986). While there are many exotic plants in California and the Pacific Northwest that are of great concern to land managers, this report focuses on two particularly aggressive plants found in Hawaii.

LEFT: The large leaves of the fast-growing miconia shade out native vegetation. ABOVE: Control of invasive miconia often requires foresters to use last-resort tactics such as herbicides. Photos courtesy of Victor Tanimoto.

Miconia is a fast-growing tree from South America that has the ability to invade many different ecosystems. It is widely regarded to be Hawaii's most threatening weed species. Miconia forms a dense, single-species stand which reduces forest biodiversity and threatens habitat for endangered species. When young, it looks like a bush, but it can easily grow to a height of 50 feet (15.2 meters). A single plant can produce thousands of tiny seeds that spread quickly. Miconia has been found on Hawaii, Maui, Oahu and Kauai, and has already destroyed 70 percent of the forest cover on Tahiti. Herbicide applied to the base of the plant with hand sprayers is the primary method of control.

Banana poka currently infests significant portions of the islands of Hawaii and Kauai (Warshauer et al. 1983). It grows between 1,970 and 6,560 feet (600 and 2,000 meters) in elevation, and is distributed continuously over most of its range. Although its foliage cover is often less than 25 percent over much of its range, its creeping foliage can smother large tracts of native forests. Biological control appears to be the only hope of controlling this species; it is much



Native vegetation on this Pacific island hillside is under heavy competition from tree-size miconia visible on the upper edge of this landslide (distinguishable by its shiny leaves). Photo courtesy of Victor Tanimoto.

too widespread for mechanical or chemical control. Four biological control agents have been released; at least one of them, a plant defoliating fungus, *Septoria passiflorae*, is now successfully established.

The beauty of the banana poka flower contrasts sharply with its destructive potential when it invades native forests. Photo courtesy of Victor Tanimoto.

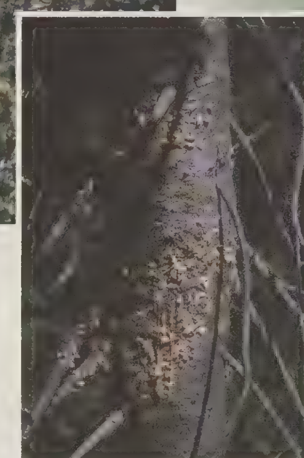
Banana poka can overgrow and smother a tropical forest. Photo courtesy of Victor Tanimoto.

Exotic Diseases

The introduction of exotic diseases has made notable changes to the composition and vigor of native West Coast forests. Once introduced, the pathogens causing these diseases are often impossible to stop. Efforts to control them are often lengthy and center around developing genetic resistance, or manipulating the environment so that the pathogen is not in its optimal habitat. Three prominent examples of introductions to Oregon, Washington and California are white pine blister rust, pitch canker and Port-Orford-cedar root disease.

White pine blister rust was introduced to the West Coast in 1921. By 1956 it had spread to most of the region's forests containing five-needle pines. Blister rust attacks trees of all ages. The first indication of damage is often the appearance of scattered dead and dying branches. Up to 95 percent of the original stands of western white pine and sugar pine have been damaged or killed by this disease (Leibold et al. 1995).

Pitch canker is a recently introduced fungal disease of pines in California; the native Monterey and Bishop pines are especially susceptible. First reported in stands of native Monterey pine in 1992, it has already spread to more than 17 California counties. Native stands and landscape plantings are affected. It appears that the disease is often spread when native insects such as twig, cone and bark beetles travel from tree to tree, with infection occurring through insect-caused wounds. The first symptom of the disease is usually a dramatic color change in branch tip foliage from green to orange. The infection sites produce large, pitchy flows of resin. Depending on the location of the



LEFT: Healthy white bark pine. RIGHT: White bark pine killed by white pine blister rust. INSET: Pinkish rust spores erupt from the bark of the white bark pine infected with blister rust. Photos courtesy of Ellen Goheen.

infections, branches or the entire tree may die. Experts believe that stands of native Monterey and Bishop pine in California are now at risk from this disease. Continued spread within Monterey and Bishop pine populations and to new tree species is expected as most pine species are susceptible, and many insects feed and breed on more than one tree species.

The natural range of Port-Orford-cedar is limited to coastal Northern California and southern Oregon. Since 1952, an introduced pathogen, *Phytophthora lateralis*, the cause of Port-Orford-cedar root disease, has been spreading over its range, primarily aided by the movement of spore-contaminated soil and water. Most mortality appears along watercourses, around lakes and along rural roads (Roth et al. 1987). Presently, about 5 percent of the host range is affected by the Port-Orford-cedar root disease. Once infected, younger trees die within a few months and mature trees die within one to four years. Most management activities try to limit the exposure of healthy trees to the pathogen (Roth et al. 1987).

Because of Port-Orford-cedar's limited range, many plot networks such as FHM or the national forest inventories do not adequately sample Port-Orford-cedar and cannot detect changes in the species or the extent and severity of the root disease. However, annual aerial surveys over all forested land in Oregon and Washington, and on national forests in California, detect current mortality of large Port-Orford-cedar so that spread of the disease can be tracked over time. Annual aerial surveys are supplemented

with periodic ground surveys to detect mortality that is not visible from the air. An assessment of the health of Port-Orford-cedar throughout its natural range is currently underway by the USDA Forest Service and the USDI Bureau of Land Management.

Young Port-Orford-cedar killed by Port-Orford-cedar root disease. Photo courtesy of Tom Iraci.

Exotic Insects

Exotic insects are introduced through a variety of mechanisms, including infested nursery stock, soil and untreated wood pallets and packaging. While strict quarantines and inspections are mandatory, it is impossible to completely eliminate the risk of introductions. If only a few potentially harmful exotic insects are found, large trapping and treatment efforts will usually follow to prevent the establishment of a local population. Once established, populations of dangerous exotic insects are very difficult or even impossible to eliminate. For example, European gypsy moth, which was introduced in 1869, is now found in 16 eastern states and has caused billions of dollars in damage (Waller 1996). The agriculture departments of each state in the West Coast region maintains lists of non-native insects that are known to affect forested environments.

A native to western Europe, the balsam woolly adelgid has been on the West Coast since 1929, and continues to play an important role in the dynamics of the true fir forests in certain parts of the Pacific Northwest. This tiny insect inserts a long thread-like mouth part into the living bark to feed, pumping a toxic salivary component into the tree. Balsam woolly adelgid can kill a tree outright, cause branch mortality or affect cone and seed production.

Impacts from this insect are often subtle, slow and overlooked after the first wave of mortality in an area (see photo series, next page). Aerial surveys only detect a small fraction of the damage caused by the balsam woolly adelgid and it often is misidentified from the air. A recent survey, funded by the FHM program, is underway to determine the extent and impact of this insect on true fir populations in Oregon and Washington.

In Hawaii, the recently introduced two-spotted leafhopper can feed on more than 300 species of plants and is changing the landscape of Hawaiian forests and watersheds. Particularly hard hit are the Hawaiian tree fern and firetree. Curiously, no other members of this

Balsam Woolly Adelgid: Three Decades of Damage

1965

Initial wave of infestation and mortality of subalpine fir by the balsam woolly adelgid. Subalpine fir was the pioneer tree species in this wet meadow. Photos courtesy of Russ Mitchell.

1968

The most susceptible subalpine firs have been killed.

1978

Mortality of remaining subalpine firs continues more slowly.

1998

Little or no subalpine fir is left. The remaining conifers are Engelmann spruce.

TOP: The entry hole of the tiny black twig borer.

CENTER: Adult and larvae of the black twig borer.

BOTTOM: The size of the two-spotted leafhopper belies its potential to damage Hawaii's native vegetation.

Photos courtesy of Victor Tanimoto.

genus are reported to be a pest anywhere other than the Hawaiian Islands. Little is known of the biology of this insect. Current studies indicate that biological control may be the only cost-effective alternative for control in large forested areas (Jones et al. 1997).

The black twig borer is a particularly aggressive ambrosia beetle that was introduced to Hawaii from tropical Asia. Seedlings and twigs of shrubs and trees are readily killed after a single gallery is formed by an adult female. Leaves and stems typically die above the beetle's entry hole. Parasitic wasps were introduced in an attempt to control the borer. They were not able to form viable reproductive populations, and the program was abandoned (Hara and Beardsley 1979).

Potentially Harmful Species

The following non-native pests are examples of insect and plant species that may cause ecosystem degradation in the future. Prevention strategies need to be implemented so these exotics and others do not have a chance to become established.

The Asian longhorned beetle was detected in Washington twice and in California once in the past two years. The beetle arrives in pallets and untreated wood products from China. It has the potential to damage several hardwood species in the Pacific Northwest, particularly the urban forest

as demonstrated by the recent infestations of Asian longhorned beetle in the New York City and Chicago areas. Once a tree is affected, the only option is to cut the tree down then chip and burn the wood (personal communication, Eric LaGasa, entomologist, Washington Department of Agriculture 1998).

Pampus grass has become established and is spreading along Highway 101 in southern Oregon and Northern California. In Northern California it has become a problem in regenerating clearcuts. This plant has the potential to aggressively invade disturbed landscapes (personal communication, Tim Butler, Oregon Department of Agriculture 1998). Apparently, this is what happened in Australia where it was present for many years without being a problem before it became a noxious, invasive weed. This aggressive grass makes such a beautiful garden plant that dispersal of domestic seed sources will assure wild plants into the future.

Table 3. Recently Introduced Insect Pests of Eucalyptus in California

Pest Name	Date Found
Eucalyptus psyllid	April 8, 1983
Tristania psyllid	May 19, 1983
Eucalyptus borer	Nov. 3, 1984
Blue gum psyllid	Jan. 25, 1991
Eucalyptus psyllid	July 22, 1991
Australian gum tree weevil	March 15, 1994
Australian eucalyptus beetle	June 24, 1995
Eucalyptus gall wasp	Feb. 2, 1995
Lemon gum psyllid	July 13, 1995
Redgum lerp psyllid	June 17, 1998
Australian tortoise beetle	Feb. 1998

The Asian gypsy moth could cause enormous problems in California and the Pacific Northwest if it becomes established. It feeds on hundreds of tree species and other plants, ranging from Douglas-fir to willow. In the past 10 years only two males have been caught in Alaska, but the insect is found every year or so in detection survey traps in western Washington and southwestern British Columbia. Only one moth has been trapped in Oregon, which occurred in 1991. Populations on the rise in eastern Russia increase the probability of introduction via world trade (personal communication, Eric LaGasa 1998).

Eleven insects that damage eucalyptus have been introduced into California in the past 15 years (California Dept. of Food and Agriculture 1998) — almost one introduction per year (Table 3). The pace of introductions seems to have increased during the 1990s. Eucalyptus trees also are exotic and were purposefully introduced into California in the 19th century. Many species are major urban and shade trees, and some are now being planted as a wood fiber crop.

The introduction of exotic species continue to occur throughout the West Coast region. Land managers should know which exotic plants, diseases and insects may disrupt the landscape. Every effort should be made to see that these species do not develop viable, reproductive populations in North America.

THE FUTURE

Assessment of forest health will continue to be an essential part of forestland stewardship and management. West Coast forests will experience outbreaks of native insects and diseases, establishment of non-native exotic organisms, and be influenced by societal changes and population growth. A variety of data will need to be collected to detect and evaluate short- and long-term disturbance and change.

Beginning in 2000, FHM plots will be a subset of the larger Forest Inventory and Analysis (FIA) plot network. A large percentage of the data collected on both FIA and FHM plots will be identical, creating a much larger dataset and allowing for finer-scale analyses (versus the limitations of coarse-scale analyses with the much smaller set of FHM data). Other plot networks, such as those on the national forests in Oregon, Washington and California, will provide similar data on the same or finer scale as FIA.

FHM will continue to monitor unique indicators of forest health such as lichen community diversity and ozone injury to vegetation. Other indicators that prove useful may be added over time. Aerial and ground surveys by federal and state agencies will continue to provide additional information on tree mortality, damage by native insects and diseases, and impact of invasive exotics. Other aspects of forest health such as fragmentation, urbanization, and reversion back to forest can be monitored and analyzed using satellite imagery as well as aerial photography and plot data.

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APPENDICES

A. Forest Health Monitoring Program (FHM)

B. Forest Health Monitoring Plot Tables: 1997, 1998 & 1999

C. Aerial Survey Tables: 1997, 1998 & 1999

D. Scientific & Common Names of Trees, Plants, Insects & Diseases

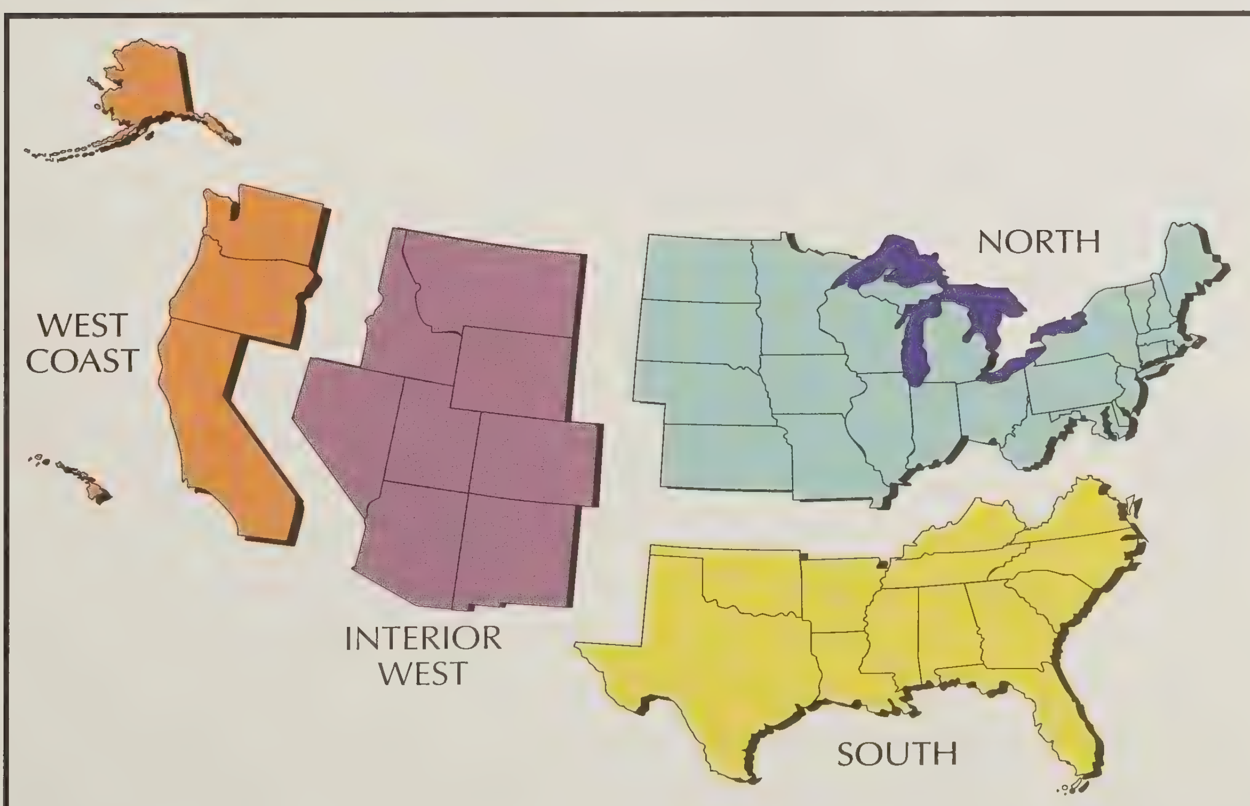
APPENDIX A

Forest Health Monitoring Program (FHM)

The national Forest Health Monitoring Program (FHM) began in 1990 in six northeastern states. It was a national cooperative effort that included the United States Department of Agriculture Forest Service; the U.S. Environmental Protection Agency; state forestry agencies; and the National Association of State Foresters. Today, cooperators also include the U.S. Department of Interior's Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, the USDA National Resources Conservation Service and state forestry organizations. The main objective is to determine status, trend and condition of forest resources nationwide.

The nation is divided into four regions administered by Forest Service Research (Fig. 6). The national Forest Health Monitoring West Coast administrative region includes Alaska, California, Hawaii, Oregon and Washington. Field plot work began in California in 1992 and the complete four-year dataset that comprises the forest ecosystem baseline for California was completed in 1995. Each baseline year is a separate estimate of forest conditions in the state. Field plot work in Oregon and Washington began in the western parts of those states with a pilot study in 1994 in which Douglas-fir

Figure 6. Forest Health Monitoring Regions



habitats were assessed on 25 plots. All forested plots in these states were measured in 1997 to provide baseline data. A subsample of these plots will be remeasured each year thereafter. Hawaii and Alaska will begin plot measurements within the next few years.

Three separate but parallel activities comprise the national FHM program. In **detection monitoring,** field crews measure selected biotic and abiotic features called indicators of forest condition on a set of plots during a baseline period. These same features are then remeasured at yearly or other intervals. Forest changes between the baseline and remeasurement condition indicate a response to natural forest change or ecosystem disturbance. The ecosystem indicators are analogous to general blood pressure, pulse and blood-chemistry data recorded for people in routine medical exams. Values outside the normal ranges indicate possible anomalies that should be monitored more closely. Detection monitoring includes aerial and ground detection surveys as well as plot measurements.

Evaluation monitoring begins when the cause or extent of a significant and detected change is unknown. Activities include intensive field sampling and combined interpretations by ecologists, entomologists, hydrologists, pathologists, silviculturists and others. These resource specialists are like medical experts who are asked to diagnose blood-chemistry results that fall outside normal values.

Intensive site ecosystem monitoring combines knowledge from evaluation monitoring and results from long-term watershed-scale research at a few sites with diverse forest types and biomes typical of those found in the United States. An example on the West Coast is the H.J. Andrews Experimental Forest near Blue River, Oregon, where forest research has been documented since the 1940s.

Combining information from all three monitoring activities helps scientists predict where and how future ecosystems might change under certain environmental and management conditions. One example could be a changing climate that produces drier fall and winter seasons; a possible effect is severely reduced seedling germination and recruitment, compared with those percentages that have been observed over several decades. In industrialized and urbanized regions, another example might be increasing ozone concentrations that damage seedlings and overstory trees, making both more susceptible to insects and diseases.

APPENDIX B
Forest Health Monitoring Plot Tables: 1997, 1998 & 1999

The tables in this appendix contain information to assess forest ecosystem conditions for West Coast states that had FHM field measurements in summer 1997, 1998 and 1999. Similar tables are available to compare ecosystem conditions across the other three FHM administrative regions (Appendix A) for the same measurement year, or past and future years, at this website: willow.ncfes.umn.edu/fhm/fhm_hp.htm.

A general explanation of information in the tables is below.

Site and Species Characteristics — The first two tables of each year present a general snapshot about the sites that were measured each summer. The "A" tables for each year show how many plots were in forest, nonforest, woodland (noncommercial timber) and inaccessible forestland uses. Information is shown by state and is aggregated to a regional total. The "B" tables show the relative percentage of forested land by major forest types; they also indicate percentage of natural versus planted stands and the percentage of plots in four stand sizes.

Stand Characteristics — Information in the "C" tables answers these questions: What kinds of trees were measured and how many were there. Data are summarized by number of individuals measured and by major species within softwood and hardwood groups. Live tree classes represent seedling, sapling and pole or larger-sized trees. Numbers of standing dead (snags) trees also are shown.

Crown Ratings — The light reaching a seedling or tree is influenced by a tree's relative position in the canopy, proximity to neighbors, and the shape, size and condition of its crown. Thus, crown evaluations indicate the appearance of measured crowns. The crown ratings indirectly assess seedling and tree ability to capture light and produce carbohydrates by photosynthesis (Fig. 7).

Sapling crown vigor is shown in the "D" tables. The number of trees assessed are shown by major species within softwood and hardwood groups. The percent of these individuals having good, average and poor ratings also is shown; these ratings are equivalent to trees tallied in vigor classes 1, 2 and 3.

Crown dieback is the total percentage (in 5-percent classes) of branch tips dying back from the crown perimeter, except dieback caused by shading and competition from neighboring trees. Dieback can be caused by severe shock to root systems from drought or disease. The "E" tables list the number of trees assessed, by major species within softwood and hardwood groups, and the percent of these trees having none, light, moderate and severe ratings.

Foliage transparency measures light filtering through needles and leaves in the crown. Transparency values differ by species and depend on natural branching habit and foliage orientation. High transparency values indicate unhealthy crown conditions because less foliage area is available for photosynthesis. The

"F" tables list the number of individuals assessed, by major species within softwood and hardwood groups, and the percent of these individuals having normal, moderate and severe ratings.

Crown density represents the relative amount of foliage, branches and reproductive structures that obstruct skylight visibility through the crown. Young and older trees with vigorous growth generally have full crowns and high density values, a condition indicating more foliage area available for photosynthesis. The "G" tables list the number of individuals assessed, by major species within softwood and hardwood groups, and the percent of these individuals having poor, average, and good ratings.

Damage — Pathogens, insects, air pollution and other natural or human disturbances can affect tree growth and development. Damage caused by any agent, alone or in combination, can influence forest condition. Recording observable damage signs and symptoms indicates if trees appear to be injured or sick. Up to three damages are recorded for all saplings and larger trees. The "H" tables present detailed information on the actual kinds of damage observed in 11 classes, by major species within softwood and hardwood groups.

Lichens, ozone injury and soil conditions — The West Coast FHM program also measures these components for forest ecosystem assessment. Refinement of measurement protocols is near completion and plot tables are under development.

Figure 7. Crown Density, Crown Dieback & Foliage Transparency Rating Example

Crown density: A two-dimensional view of foliage, branches and reproductive structures (percent) that obstructs light penetration through the crown. This tree has a density of about 50 percent.

Crown dieback: The percentage of branch tips dying back from the crown edge. Normal death by shading is not counted.

Foliage Transparency: A measure of sunlight (percent) filtering through needles and leaves in the crown.

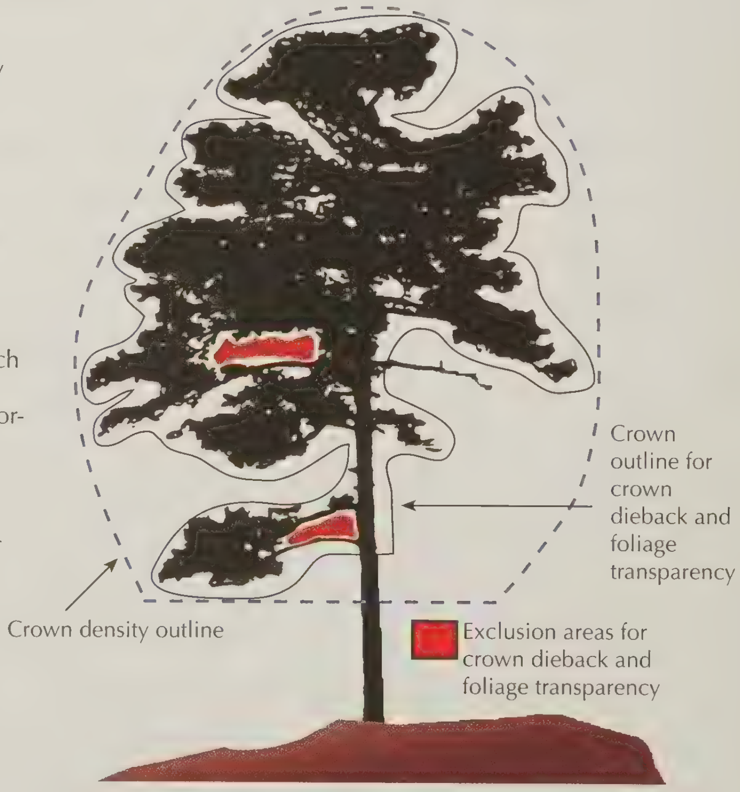


Table 1997a. Plot distribution for the West Coast Region in 1997 by state.

1997	Land Use Class				
	Forest Land	**Woodland**	**Inaccessible Forest**	**Non-forest**	
	Sum of Plots	**Sum of Plots**	**Sum of Plots**	**Sum of Plots**	**State Total**
State					
California	55.18	4.00	2.25	146.57	208.00
Oregon	143.62	17.65	9.81	217.92	389.00
Washington	125.70	0.00	12.51	130.79	269.00
Region Total	**324.49**	**21.65**	**24.57**	**495.28**	**866.00**

Note: Values represent the number of plots; however they may not add to whole numbers because of the partially forested plots. In Oregon and Washington, all forested plots were surveyed in 1997 to provide base line data; in 1998 and 1999, a subset of all plots (panel and overlap) were re-measured. In California, a subset of all plots (panel and overlap) were measured in 1996, 1997, 1998 and 1999; baseline data was collected 1992 through 1995.

Table 1997b. Distribution of forestland plots (in % of total forestland plots) by stand level categories in 1997 in the West Coast region.

1997 **Stand Level Category**	**Region Totals**	**California**	**Oregon**	**Washington**
Douglas Fir	29.51	5.07	31.20	38.86
Maj. Pine Types	19.97	30.45	20.58	14.25
Fir-Spruce	5.99	8.02	4.18	7.36
Hemlock-Spruce	11.32	0.00	4.90	24.90
Redwood-Sequoia	0.58	3.38	0.00	0.00
Misc. Hardwoods	7.50	25.38	5.36	1.81
Misc. Softwoods	1.86	5.07	1.24	1.17
Mixed Conifers	16.28	15.05	20.95	10.85
Other Timberland	0.72	0.81	0.62	0.79
Woodland	6.25	6.75	10.94	0.00
Stand Origin				
Natural Stands	85.25	91.31	86.73	80.51
Planted Softwoods.	14.75	8.69	13.27	19.49
Stand Size				
Sawtimber	64.04	81.41	55.26	67.11
Poletimber	26.51	17.35	32.75	22.83
Seedling-Sapling	8.73	0.42	11.37	9.26
Nonstocked	0.72	0.81	0.62	0.80

Table 1997c. Number of trees by status (live or standing dead), dbh class, and species for 1997 in the West Coast region.

1997	**Live Trees**			**Standing Dead**
Species	**<1.0”**	**1 - 4.9”**	**5”+**	**5”+**
Softwoods				
Douglas-fir	462	182	2126	237
Ponderosa & Jeffery Pines	173	125	869	80
True Firs	787	154	887	155
Western Hemlock	416	151	845	103
Sugar Pine	17	7	54	2
Western White Pine	3	5	26	15
Redwood	0	0	20	1
Sitka Spruce	3	4	49	4
Other Spruce	27	12	103	18
Western larch	8	0	84	23
Incense Cedar	44	11	76	2
Lodgepole Pine	490	104	678	135
Western Redcedar	122	40	304	45
Other Softwoods	65	31	195	18
Woodland Species	22	10	235	1
Softwoods Subtotal	*2639*	*836*	*6551*	*839*
Hardwoods				
Cottonwoods & Aspen		0	20	3
Red Alder	99	48	370	48
Timberland Oaks	324	84	373	15
Other Hardwoods	360	125	482	45
Woodland Species	20	0	0	0
Hardwoods Subtotal	*803*	*257*	*1245*	*111*
Unknown	*43*	*4*	*10*	*9*
Total	**3486**	**1097**	**7806**	**959**

Table 1997d. Percentage of saplings by crown-vigor classes by tree species for 1997 in the West Coast region.

1997		**Sapling Vigor Class (in % of n)**		
Species	**n**	**Good**	**Average**	**Poor**
Softwoods				
Douglas-fir	182	69	29	2
Ponderosa & Jeffery Pines	125	69	27	4
True Firs	154	68	27	5
Western Hemlock	151	21	75	4
Sugar Pine	7	43	57	0
Western White Pine	5	100	0	0
Sitka Spruce	4	100	0	0
Other Spruce	12	67	33	0
Incense Cedar	11	91	9	0
Lodgepole Pine	104	77	19	4
Western Redcedar	40	78	23	0
Other Softwoods	31	81	19	0
Woodland Species	10	70	30	0
Softwoods Subtotal	*836*	*62*	*34*	*4*
Hardwoods				
Red alder	48	60	35	4
Timberland Oaks	84	68	31	1
Other Hardwoods	125	62	33	5
Hardwoods Subtotal	*257*	*64*	*33*	*2*
Unknown	*4*	*75*	*25*	*0*
Total	**1097**	**63**	**34**	**3**

Table 1997e. Percentage of trees in each crown dieback class by species for 1997 in the West Coast region.

1997		**Crown Dieback Class (in % of n)**			
Species	**n**	**None (0-5)**	**Light (6-20)**	**Moderate 21-50)**	**Severe (51-100)**
Softwoods					
Douglas-fir	2126	95	4	1	<1
Ponderosa & Jeffery Pines	869	97	2	<1	<1
True Firs	887	89	9	2	1
Western Hemlock	845	93	6	1	<1
Sugar Pine	54	100	0	0	0
Western White Pine	26	88	8	4	0
Redwood	20	95	5	0	0
Sitka Spruce	49	92	8	0	0
Other Spruce	103	97	2	1	0
Western larch	84	89	10	1	0
Incense Cedar	76	97	3	0	0
Lodgepole Pine	678	92	7	1	<1
Western Redcedar	304	91	7	1	1
Other Softwoods	195	95	3	1	1
Woodland Species	235	94	3	2	<1
Softwoods Subtotal	*6551*	*94*	*5*	*1*	*<1*
Hardwoods					
Cottonwoods & Aspen	20	90	10	0	0
Red alder	370	92	4	2	3
Timberland Oaks	373	83	13	2	2
Other Hardwoods	482	87	10	1	2
Hardwoods Subtotal	*1245*	*87*	*9*	*1*	*2*
Unknown	*10*	*100*	*0*	*0*	*0*
Total	**9051**	**93**	**6**	**1**	**1**

Table 1997f. Percentage of trees in each foliage transparency class by species for 1997 in the West Coast region.

1997		Foliage Transparency Class (% of n)		
Species	**n**	**Normal (0-30)**	**Moderate (31-50)**	**Severe (51-100)**
Softwoods				
Douglas-fir	2126	99	<1	<1
Ponderosa & Jeffery Pines	869	98	2	<1
True Firs	887	100	0	<1
Western Hemlock	845	100	0	0
Sugar Pine	54	98	2	0
Western White Pine	26	100	0	0
Redwood	20	95	5	0
Sitka Spruce	49	100	0	0
Other Spruce	103	100	0	0
Western larch	84	96	4	0
Incense Cedar	76	99	1	0
Lodgepole Pine	678	99	1	0
Western Redcedar	304	96	3	0
Other Softwoods	195	100	0	0
Woodland Species	235	100	0	0
Softwoods Subtotal	*6551*	*99*	*1*	*<1*
Hardwoods				
Cottonwoods & Aspen	20	95	5	0
Red alder	370	94	3	2
Timberland Oaks	373	95	4	1
Other Hardwoods	482	90	8	2
Hardwoods Subtotal	*1245*	*93*	*5*	*2*
Unknown	*10*	*100*	*0*	*0*
Total	**7806**	**98**	**2**	**<1**

Table 1997g. Percentage of trees in crown density classes by species for 1997 in the West Coast region

1997		**Crown Density (% of n)**		
Species	n	Poor (0-20)	Average (21-50)	Good (51-100)
<u>*Softwoods*</u>				
Douglas-fir	2126	3	47	50
Ponderosa & Jeffery Pines	869	4	45	51
True Firs	887	4	46	50
Western Hemlock	845	6	52	42
Sugar Pine	54	4	63	33
Western White Pine	26	0	46	54
Redwood	20	20	70	10
Sitka Spruce	49	2	53	45
Other Spruce	103	3	42	55
Western larch	84	7	52	41
Incense Cedar	76	0	50	50
Lodgepole Pine	678	6	56	38
Western Redcedar	304	7	56	37
Other Softwoods	195	8	77	15
Woodland Species	235	3	26	71
Softwoods Subtotal	*6551*	*4*	*49*	*47*
<u>*Hardwoods*</u>				
Cottonwoods & Aspen	20	5	45	50
Red alder	370	6	53	41
Timberland Oaks	373	9	72	19
Other Hardwoods	482	11	56	33
Hardwoods Subtotal	*1245*	*9*	*59*	*32*
Unknown	*10*	*0*	*50*	*50*
Total	**7806**	**5**	**51**	**44**

Table 1997h. Percentage of trees in number-of-damages classes by species for 1997 in the West Coast region.

1997		**Number of Damages (% of n)**			
Species	**n**	**0**	**1**	**2**	**3**
Softwoods					
Douglas-fir	2126	89	10	1	<1
Ponderosa & Jeffery Pines	869	88	10	2	0
True Firs	887	82	15	2	<1
Western Hemlock	845	81	16	2	<1
Sugar Pine	54	93	7	0	0
Western White Pine	26	69	19	12	0
Redwood	20	85	10	5	0
Sitka Spruce	49	80	20	0	0
Other Spruce	103	73	26	1	0
Western larch	84	88	10	2	0
Incense Cedar	76	87	11	3	0
Lodgepole Pine	678	69	24	5	2
Western Redcedar	304	79	16	4	1
Other Softwoods	195	81	16	3	0
Woodland Species	235	91	8	1	0
Softwoods Subtotal	*6551*	*84*	*14*	*2*	*<1*
Hardwoods					
Cottonwoods & Aspen	20	75	20	5	0
Red alder	370	89	9	2	0
Timberland Oaks	373	75	16	8	1
Other Hardwoods	482	72	21	5	2
Hardwoods Subtotal	*1245*	*78*	*16*	*5*	*1*
Unknown	*10*	*100*	*0*	*0*	*0*
Total	**7806**	**83**	**14**	**3**	**1**

Table 1997i. Number of trees by damage type by species for 1997 in the West Coast region.

1997	**Damage Type**											
Species	Total Damage	Canker	Decay	Wounds	Resinosis	Broken Root/bole	Top Loss	Broken Branches	Excess Branches	Shoot Damage	Discolored Foliage	Other
Softwoods												
Douglas-fir	258	9	52	22	11	1	117	11	28	2	1	4
Ponderosa & Jeffery Pines	119	3	19	17	6	1	37	6	19	2	6	3
True Firs	188	11	42	14	5	1	88	7	18	2	0	0
Western Hemlock	182	4	40	13	0	2	44	2	75	0	0	1
Sugar Pine	4	0	0	0	0	0	3	1	0	0	0	0
Western White Pine	11	3	4	2	2	0	0	0	0	0	0	0
Redwood	4	0	1	0	0	0	2	1	0	0	0	0
Sitka Spruce	10	0	6	0	0	0	3	1	0	0	0	0
Other Spruce	29	0	17	3	0	1	4	0	4	0	0	0
Western larch	12	2	0	1	0	0	3	0	6	0	0	0
Incense Cedar	12	0	2	2	0	0	5	2	1	0	0	0
Lodgepole Pine	253	46	30	82	5	3	53	7	24	0	2	1
Western Redcedar	82	0	24	9	1	6	26	3	3	0	1	8
Other Softwoods	43	0	26	7	0	0	6	3	0	0	0	1
Woodland Species	23	0	4	1	0	0	5	11	1	0	0	1
Softwoods Subtotal	*1230*	*78*	*267*	*173*	*30*	*16*	*396*	*55*	*179*	*6*	*10*	*20*
Hardwoods												
Cottonwoods & Aspen	6	0	2	0	0	0	3	1	0	0	0	0
Red alder	47	2	14	6	0	1	17	6	0	0	0	1
Timberland Oaks	117	1	58	11	0	0	14	31	2	0	0	0
Other Hardwoods	174	2	80	24	0	5	46	14	0	0	1	0
Hardwoods Subtotal	*344*	*5*	*154*	*41*	*0*	*6*	*80*	*52*	*2*	*0*	*3*	*1*
Total	**1574**	**83**	**421**	**214**	**30**	**22**	**476**	**107**	**181**	**6**	**13**	**21**

Table 1998a. Plot distribution for the West Coast Region in 1998 by state.

1998	Land Use Class				
	Forest Land	Woodland	Inaccessible Forest	Non-forest	
	Sum of Plots	Sum of Plots	Sum of Plots	Sum of Plots	State Total
State					
California	53.46	4.53	10.75	141.26	210.00
Oregon	54.81	6.00	3.00	61.19	125.00
Washington	44.89	0.00	2.50	44.61	92.00
Region Total	**153.16**	**10.53**	**16.25**	**247.06**	**427.00**

Note: Values represent the number of plots; however they may not add to whole numbers because of the partially forested plots. In Oregon and Washington, all forested plots were surveyed in 1997 to provide base line data; in 1998 and 1999, a subset of all plots (panel and overlap) were re-measured. In California, a subset of all plots (panel and overlap) were measured in 1996, 1997, 1998 and 1999; baseline data was collected 1992 through 1995.

Table 1998b. Distribution of forestland plots (in % of total forestland plots) by stand level categories in 1998 in the West Coast region.

1998 **Stand Level Category**	**Region Totals**	**California**	**Oregon**	**Washington**
Douglas Fir	30.23	3.88	38.13	53.58
Maj. Pine Types	19.57	22.33	23.76	10.34
Fir-Spruce	10.99	10.35	9.87	13.37
Hemlock-Spruce	7.34	1.72	6.27	16.04
Redwood-Sequoia	1.22	3.45	0.00	0.00
Misc. Hardwoods	10.99	25.85	4.94	0.00
Misc. Softwoods	1.83	0.00	3.29	2.23
Mixed Conifers	11.07	24.61	3.06	4.46
Other Timberland	0.31	0.00	0.82	0.00
Woodland	6.43	7.81	9.87	0.00
Stand Origin				
Natural Stands	88.19	97.41	86.10	79.10
Planted Softwoods.	11.81	2.59	13.90	20.90
Stand Size				
Sawtimber	54.60	62.20	46.71	55.47
Poletimber	35.15	32.02	41.30	30.87
Seedling-Sapling	9.94	5.78	11.16	13.66
Nonstocked	0.31	0.00	0.82	0.00

Table 1998c. Number of trees by status (live or standing dead), dbh class, and species for 1998 in the West Coast region.

1998	Live Trees			Standing Dead
Species	**<1.0”**	**1 - 4.9”**	**5”+**	**5”+**
Softwoods				
Douglas-fir	271	132	891	122
Ponderosa & Jeffery Pines	43	48	358	26
True Firs	296	77	509	82
Western Hemlock	88	16	222	34
Sugar Pine	7	5	61	9
Western White Pine	3	0	20	1
Redwood	0	0	35	1
Sitka Spruce	0	1	9	0
Other Spruce	4	4	69	11
Western larch	0	1	58	15
Incense Cedar	95	25	106	18
Lodgepole Pine	66	38	214	60
Western Redcedar	60	19	170	27
Other Softwoods	38	25	90	12
Woodland Species	13	5	144	4
Softwoods Subtotal	*984*	*396*	*2956*	*422*
Hardwoods				
Cottonwoods & Aspen	10	4	33	6
Red alder	7	25	117	12
Timberland Oaks	144	73	366	12
Other Hardwoods	115	80	205	13
Woodland Species	0	0	4	0
Hardwoods Subtotal	*276*	*182*	*725*	*43*
Unknown	*4*	*5*	*12*	*10*
Total	**1264**	**583**	**3693**	**475**

Table 1998d. Percentage of saplings by crown-vigor classes by tree species for 1998 in the West Coast region.

1998		Sapling Vigor Class (in % of n)		
Species	**n**	**Good**	**Average**	**Poor**
Softwoods				
Douglas-fir	132	45	47	8
Ponderosa & Jeffery Pines	48	56	40	4
True Firs	77	43	53	4
Western Hemlock	16	62	38	0
Sugar Pine	5	100	0	0
Western White Pine	0	0	0	0
Sitka Spruce	1	100	0	0
Other Spruce	4	25	0	75
Western larch	1	100	0	0
Incense Cedar	25	68	24	8
Lodgepole Pine	38	63	26	11
Western Redcedar	19	50	50	0
Other Softwoods	25	20	52	28
Woodland Species	5	80	20	0
Softwoods Subtotal	*396*	*50*	*42*	*8*
Hardwoods				
Cottonwoods & Aspen	4	75	25	0
Red alder	25	24	60	16
Timberland Oaks	73	55	42	3
Other Hardwoods	80	50	39	11
Woodland Species	0	0	0	0
Hardwoods Subtotal	*182*	*49*	*43*	*8*
Unknown	*5*	*40*	*60*	*0*
Total	**583**	**49**	**43**	**8**

Table 1998e. Percentage of trees in each crown dieback class by species for 1998 in the West Coast region.

1998		Crown Dieback Class (in % of n)			
Species	**n**	**None (0-5)**	**Light (6-20)**	**Moderate (21-50)**	**Severe (51-100)**
<u>Softwoods</u>					
Douglas-fir	891	97	2	<1	<1
Ponderosa & Jeffery Pines	358	96	3	<1	<1
True Firs	509	97	2	1	0
Western Hemlock	222	98	2	0	0
Sugar Pine	61	95	3	2	0
Western White Pine	20	95	5	0	0
Redwood	35	89	9	0	3
Sitka Spruce	9	89	11	0	0
Other Spruce	69	92	7	0	1
Western larch	58	95	3	2	0
Incense Cedar	106	96	3	1	0
Lodgepole Pine	214	96	4	<1	0
Western Redcedar	170	93	6	0	1
Other Softwoods	90	99	1	0	0
Woodland Species	144	92	7	1	0
Softwoods Subtotal	*2956*	*95*	*4*	*1*	*<1*
<u>Hardwoods</u>					
Cottonwoods & Aspen	33	91	6	3	0
Red alder	117	95	5	0	0
Timberland Oaks	366	84	14	2	<1
Other Hardwoods	205	93	5	1	1
Woodland Species	4	100	0	0	0
Hardwoods Subtotal	*725*	*89*	*10*	*1*	*<1*
Unknown	*12*	*67*	*25*	*8*	*0*
Total	**3693**	**89**	**10**	**1**	**<1**

Table 1998f. Percentage of trees in each foliage transparency class by species for 1998 in the West Coast region.

1998		Foliage Transparency Class (% of n)		
Species	**n**	**Normal (0-30)**	**Moderate (31-50)**	**Severe (51-100)**
Softwoods				
Douglas-fir	891	99	1	<1
Ponderosa & Jeffery Pines	358	96	4	<1
True Firs	509	99	1	0
Western Hemlock	222	100	0	0
Sugar Pine	61	97	3	0
Western White Pine	20	100	0	0
Redwood	35	91	9	0
Sitka Spruce	9	100	0	0
Other Spruce	69	99	1	0
Western larch	58	88	12	0
Incense Cedar	106	96	4	0
Lodgepole Pine	214	96	3	1
Western Redcedar	170	98	2	0
Other Softwoods	90	98	2	0
Woodland Species	144	100	0	0
Softwoods Subtotal	*2956*	*98*	*2*	*<1*
Hardwoods				
Cottonwoods & Aspen	33	100	0	0
Red alder	117	96	4	0
Timberland Oaks	366	96	4	0
Other Hardwoods	205	99	1	0
Hardwood Woodland	4	100	0	0
Hardwoods Subtotal	*725*	*97*	*3*	*0*
Unknown	*12*	*100*	*0*	*0*
Total	**3693**	**98**	**2**	**<1**

Table 1998g. Percentage of trees in crown density classes by species for 1998 in the West Coast region

1998		**Crown Density (% of n)**		
Species	n	Poor (0-20)	Average (21-50)	Good (51-100)
Softwoods				
Douglas-fir	891	2	59	39
Ponderosa & Jeffery Pines	358	6	63	31
True Firs	509	2	57	41
Western Hemlock	222	2	61	37
Sugar Pine	61	3	67	30
Western White Pine	20	0	75	25
Redwood	35	26	68	6
Sitka Spruce	9	11	56	33
Other Spruce	69	4	60	36
Western larch	58	0	66	34
Incense Cedar	106	4	76	20
Lodgepole Pine	214	3	74	23
Western Redcedar	170	4	68	28
Other Softwoods	90	0	74	26
Woodland Species	144	2	60	38
Softwoods Subtotal	2956	3	63	34
Hardwoods				
Cottonwoods & Aspen	33	0	94	6
Red alder	117	0	51	49
Timberland Oaks	366	7	89	4
Other Hardwoods	205	7	78	15
Hardwood Woodland	4	0	100	0
Hardwoods Subtotal	*725*	*6*	*80*	*14*
Unknown	*12*	*17*	*58*	*25*
Total	**3693**	**4**	**66**	**30**

Table 1998h. Percentage of trees in number-of-damages classes by species for 1998 in the West Coast region.

1998		**Number of damages (% of n)**			
Species	**n**	**0**	**1**	**2**	**3**
Softwoods					
Douglas-fir	891	88	10	1	1
Ponderosa & Jeffery Pines	358	85	13	2	1
True Firs	509	84	13	2	1
Western Hemlock	222	83	14	2	1
Sugar Pine	61	87	11	2	
Western White Pine	20	90	10	0	0
Redwood	35	66	23	11	0
Sitka Spruce	9	89	11	0	0
Other Spruce	69	87	12	1	0
Western larch	58	72	26	2	0
Incense Cedar	106	90	9	1	0
Lodgepole Pine	214	65	26	7	2
Western Redcedar	170	80	16	3	1
Other Softwoods	90	76	22	2	0
Woodland Species	144	92	6	1	1
Softwoods Subtotal	*2956*	*84*	*13*	*2*	*1*
Hardwoods					
Cottonwoods & Aspen	33	82	18	0	0
Red alder	117	93	7	0	0
Timberland Oaks	366	68	22	7	3
Other Hardwoods	205	73	18	6	3
Hardwood Woodland	4	75	25	0	0
Hardwoods Subtotal	*725*	*74*	*19*	*5*	*2*
Unknown	*12*	*58*	*17*	*25*	*0*
Total	**3693**	**82**	**14**	**3**	**1**

Table 1998i. Number of trees by damage type by species for 1998 in the West Coast region.

1998		**Damage Type**										
Species	Total Damage	Canker	Decay	Wounds	Resinosis	Broken Root/bole	Top Loss	Broken Branches	Excess Branches	Shoot Damage	Discolored Foliage	Other
Softwoods												
Douglas-fir	120	21	9	9	11	0	45	6	10	0	6	3
Ponderosa & Jeffery Pines	66	4	2	12	2	4	19	5	1	3	9	5
True Firs	98	21	21	6	2	1	32	6	5	3	0	1
Western Hemlock	45	6	10	4	0	0	12	2	10	0	0	1
Sugar Pine	9	0	0	1	1	0	5	1	0	0	0	1
Western White Pine	2	0	0	0	1	0	1	0	0	0	0	0
Redwood	15	0	0	4	0	0	6	2	0	1	1	1
Sitka Spruce	1	0	0	0	0	0	1	0	0	0	0	0
Other Spruce	10	0	1	2	0	1	5	1	0	0	0	0
Western larch	17	4	8	1	0	1	0	1	2	0	0	0
Incense Cedar	12	0	1	2	0	1	5	2	0	0	1	0
Lodgepole Pine	93	36	9	22	8	0	12	1	3	0	0	2
Western Redcedar	40	3	5	4	0	0	21	5	0	0	1	1
Other Softwoods	24	0	20	0	0	0	1	3	0	0	0	0
Woodland Species	14	0	2	3	1	0	3	4	0	0	1	0
Softwoods Subtotal	*566*	*95*	*88*	*70*	*26*	*8*	*168*	*39*	*31*	*7*	*19*	*15*
Hardwoods												
Cottonwoods & Aspen	6	0	4	0	0	0	0	2	0	0	0	0
Red alder	8	0	5	1	0	0	2	0	0	0	0	0
Timberland Oaks	148	4	67	11	0	3	5	48	3	4	0	3
Other Hardwoods	72	1	31	10	0	1	17	7	2	2	0	1
Woodland Species	1	0	1	0	0	0	0	0	0	0	0	0
Hardwoods Subtotal	*235*	*5*	*108*	*22*	*0*	*4*	*24*	*57*	*5*	*6*	*0*	*4*
Unknown	*8*	*0*	*2*	*2*	*0*	*0*	*2*	*2*	*0*	*0*	*0*	*0*
Total	**809**	**100**	**198**	**94**	**26**	**12**	**194**	**98**	**36**	**13**	**19**	**19**

Table 1999a. Plot distribution for the West Coast Region in 1999 by state.

1999	Land Use Class				
	Forest Land	Woodland	Inaccessible Forest	Non-forest	
	Sum of Plots	Sum of Plots	Sum of Plots	Sum of Plots	State Total
State					
California	52.98	9.00	4.00	152.02	218.00
Oregon	57.94	5.06	3.25	61.75	128.00
Washington	47.78	0.00	1.26	48.96	99.00
Region Total	**158.70**	**14.06**	**8.51**	**263.73**	**445.00**

Note: Values represent the number of plots; however they may not add to whole numbers because of the partially forested plots. In Oregon and Washington, all forested plots were surveyed in 1997 to provide base line data; in 1998 and 1999, a subset of all plots (panel and overlap) were re-measured. In California, a subset of all plots (panel and overlap) were measured in 1997, 1998 and 1999; baseline data was collected 1992 through 1995.

Table 1999b. Distribution of forestland plots (in % of total forestland plots) by stand level categories in 1999 in the West Coast Region.

1999 **Stand Level Category**	**Region Totals**	**California**	**Oregon**	**Washington**
Douglas Fir	22.6	4.8	35.3	29.1
Maj. Pine Types	22.4	14.8	28.0	24.9
Fir-Spruce	10.5	12.7	7.5	11.5
Hemlock-Spruce	9.3	0.0	6.0	25.6
Redwood-Sequoia	.6	1.6	0.0	0.0
Misc. Hardwoods	15.6	31.3	10.9	1.6
Misc. Softwoods	3.3	4.1	2.7	3.1
Mixed Conifers	5.7	12.8	0.0	4.2
Other Timberland	1.7	3.2	1.6	0.0
Woodland	8.1	14.5	8.0	0.0
Stand Origin				
Natural Stands	88.4	94.7	86.9	82.1
Planted Softwoods.	11.6	5.3	13.1	17.9
Stand Size				
Sawtimber	60.9	64.6	54.7	64.3
Poletimber	30.5	26.6	36.5	27.8
Seedling-Sapling	6.8	5.6	7.3	7.8
Nonstocked	1.7	3.2	1.6	0.0

Table 1999c. Number of trees by status (live or standing dead), dbh class, and species for 1999 in the West Coast region.

1999	**Live Trees**			**Standing Dead**
Species	**<1.0”**	**1 - 4.9”**	**5”+**	**5”+**
Softwoods				
Douglas-fir	165	82	973	94
Ponderosa & Jeffery Pines	97	62	376	33
True Firs	250	54	459	68
Western Hemlock	160	29	382	51
Sugar Pine	4	2	19	2
Western White Pine	0	3	32	0
Redwood	0	0	32	3
Sitka Spruce	1	1	28	6
Other Spruce	11	3	37	7
Western larch	1	0	21	19
Incense Cedar	16	8	67	8
Lodgepole Pine	59	58	378	52
Western Redcedar	44	22	134	20
Other Softwoods	9	6	81	14
Woodland Species	9	5	98	5
Softwoods Subtotal	*826*	*335*	*3117*	*382*
Hardwoods				
Cottonwoods & Aspen	42	9	52	12
Redalder	8	17	161	21
Timberland Oaks	404	85	415	22
Other Hardwoods	187	72	285	21
Woodland Species	0	2	0	0
Hardwoods Subtotal	*641*	*189*	*974*	*76*
Unknown	*49*	*4*	*61*	*11*
Total	**1516**	**524**	**4091**	**469**

Table 1999d. Percentage of saplings by crown-vigor classes by species for 1999 in the West Coast region.

1999		**Sapling Vigor Class (in % of n)**		
Species	**n**	**Good**	**Average**	**Poor**
Softwoods				
Douglas-fir	82	73	26	1
Ponderosa & Jeffery Pines	62	77	23	0
True Firs	54	59	37	4
Western Hemlock	29	34	66	0
Sugar Pine	2	100	0	0
Western White Pine	3	100	0	0
Sitka Spruce	1	100	0	0
Other Spruce	3	33	67	0
Incense Cedar	8	88	12	0
Lodgepole Pine	58	67	26	7
Western Redcedar	22	32	64	4
Other Softwoods	6	50	50	0
Woodland Species	5	80	20	0
Softwoods Subtotal	*335*	*65*	*32*	*3*
Hardwoods				
Cottonwoods & Aspen	9	67	33	0
Red alder	17	65	24	11
Timberland Oaks	85	62	33	5
Other Hardwoods	72	67	29	4
Woodland Species	2	0	100	0
Hardwood Subtotal	*185*	*64*	*31*	*5*
Unknown	*4*	*75*	*25*	*0*
Total	**524**	**64**	**33**	**3**

Table 1999e. Percentage of trees in each crown dieback class by species for 1999 in the West Coast region.

1999		**Crown Dieback Class (in % of n)**			
Species	**n**	**None (0-5)**	**Light (6-20)**	**Moderate (21-50)**	**Severe (51-100)**
Softwoods					
Douglas-fir	973	97	2	<1	<1
Ponderosa & Jeffery Pines	376	98	2	<1	<1
True Firs	459	95	3	1	1
Western Hemlock	382	95	4	1	<1
Sugar Pine	19	100	0	0	0
Western White Pine	32	97	3	4	0
Redwood	32	100	0	0	0
Sitka Spruce	28	96	4	0	0
Other Spruce	37	100	0	1	0
Western larch	21	71	29	1	0
Incense Cedar	67	100	0	0	0
Lodgepole Pine	378	95	4	1	<1
Western Redcedar	134	93	6	1	0
Other Softwoods	81	96	4	0	0
Woodland Species	98	94	6	0	<1
Softwoods Subtotal	*3117*	*96*	*3*	*<1*	*<1*
Cottonwoods & Aspen	52	79	13	6	2
Red alder	161	99	1	0	0
Timberland Oaks	415	90	9	<1	0
Other Hardwoods	285	94	5	1	<1
Woodland Species	0	0	0	0	0
Hardwoods Subtotal	*913*	*91*	*8*	*1*	*<1*
Unknown	*61*	*75*	*23*	*2*	*0*
Total	**4091**	**95**	**4**	**1**	**<1**

Table 1999f. Percentage of trees in each foliage transparency class by species for 1999 in the West Coast region.

1999		**Foliage Transparency Class (% of n)**		
Species	**n**	**Normal (0-30)**	**Moderate (31-50)**	**Severe (51-100)**
Softwoods				
Douglas-fir	973	99	<1	<1
Ponderosa & Jeffery Pines	376	99	1	0
True Firs	459	98	2	0
Western Hemlock	382	100	0	0
Sugar Pine	19	100	0	0
Western White Pine	32	97	3	0
Redwood	32	100	0	0
Sitka Spruce	28	100	0	0
Other Spruce	37	97	3	0
Western larch	21	95	5	0
Incense Cedar	67	100	0	0
Lodgepole Pine	378	99	1	0
Western Redcedar	134	97	3	0
Other Softwoods	81	99	1	0
Woodland Species	98	100	0	0
Softwoods Subtotal	*3117*	*99*	*1*	*<1*
Hardwoods				
Cottonwoods & Aspen	52	79	17	4
Red alder	161	90	10	0
Timberland Oaks	415	98	2	<1
Other Hardwoods	285	98	1	<1
Hardwood Woodland	0	0	0	0
Hardwoods Subtotal	*913*	*96*	*4*	*<1*
Unknown	*61*	*100*	*0*	*0*
Total	**4091**	**98**	**2**	**<1**

Table 1999g. Percentage of trees in each crown density classes by species for 1999 in the West Coast region

1999		**Crown Density (% of n)**		
Species	n	Poor (0-20)	Average (21-50)	Good (51-100)
Softwoods				
Douglas-fir	973	3	55	42
Ponderosa & Jeffery Pines	376	8	71	21
True Firs	459	4	66	30
Western Hemlock	382	3	63	34
Sugar Pine	19	0	74	26
Western White Pine	32	3	81	16
Redwood	32	22	78	0
Sitka Spruce	28	0	46	54
Other Spruce	37	3	54	43
Western larch	21	10	67	24
Incense Cedar	67	11	64	25
Lodgepole Pine	378	5	78	17
Western Redcedar	134	4	75	21
Other Softwoods	81	0	70	30
Woodland Species	98	7	55	38
Softwoods Subtotal	*3117*	*5*	*64*	*31*
Hardwoods				
Cottonwoods & Aspen	52	9	87	4
Red alder	161	4	59	37
Timberland Oaks	415	8	85	7
Other Hardwoods	285	7	76	17
Hardwood Woodland	0	0	0	0
Hardwoods Subtotal	*913*	*8*	*78*	*14*
Unknown	*61*	*11*	*82*	*7*
Total	**4091**	**5**	**68**	**27**

Table 1999h. Percentage of trees in number-of-damages classes by species for 1999 in the West Coast Region.

1999		Number of damages (% of n)			
Species	**n**	**0**	**1**	**2**	**3**
Softwoods					
Douglas-fir	973	89	9	1	<1
Ponderosa & Jeffery Pines	376	83	16	1	<1
True Firs	459	81	15	3	1
Western Hemlock	382	74	23	4	<1
Sugar Pine	19	68	26	5	0
Western White Pine	32	59	22	19	0
Redwood	32	66	19	9	6
Sitka Spruce	28	79	14	7	0
Other Spruce	37	84	13	3	0
Western larch	21	71	19	10	0
Incense Cedar	67	90	7	3	0
Lodgepole Pine	378	59	28	8	5
Western Redcedar	134	69	22	9	0
Other Softwoods	81	74	23	3	0
Woodland Species	98	85	12	3	0
Softwoods Subtotal	*3117*	*79*	*16*	*4*	*1*
Hardwoods					
Cottonwoods & Aspen	52	58	38	2	2
Red alder	161	89	9	1	1
Timberland Oaks	415	65	23	9	3
Other Hardwoods	285	75	20	4	1
Hardwood Woodland	0	0	0	0	0
Hardwoods Subtotal	*913*	*71*	*21*	*6*	*2*
Unknown	*61*	*54*	*28*	*12*	*6*
Total	**4091**	**77**	**18**	**4**	**1**

Table 1999i. Number of trees by damage type by species for 1999 in the West Coast region.

1999 Species	Total Damage	Damage Type: Canker	Decay	Wounds	Resinosis	Broken Root/bole	Top Loss	Broken Branches	Excess Branches	Shoot Damage	Discolored Foliage	Other
Softwoods												
Douglas-fir	115	23	14	13	2	0	36	8	14	0	3	2
Ponderosa & Jeffery Pines	70	5	12	19	1	0	12	0	11	5	5	0
True Firs	108	18	11	6	4	3	44	6	8	6	1	1
Western Hemlock	115	9	14	12	0	2	25	2	50	0	0	1
Sugar Pine	7	0	0	0	1	0	6	0	0	0	0	0
Western White Pine	18	2	3	3	2	0	4	1	0	0	2	1
Redwood	16	1	2	5	0	0	4	2	0	1	0	1
Sitka Spruce	7	0	4	1	1	0	1	0	0	0	0	0
Other Spruce	7	0	0	1	0	0	5	1	0	0	0	0
Western larch	8	1	0	1	0	0	3	0	3	0	0	0
Incense Cedar	9	0	2	1	0	0	6	0	0	0	0	0
Lodgepole Pine	201	61	6	52	10	1	37	6	13	1	1	13
Western Redcedar	54	1	2	2	0	0	20	2	23	1	1	2
Other Softwoods	23	0	15	3	0	1	3	1	0	0	0	0
Woodland Species	18	0	2	1	1	0	6	4	4	0	0	0
Softwoods Subtotal	*776*	*121*	*87*	*120*	*22*	*7*	*212*	*33*	*126*	*14*	*13*	*21*
Hardwoods												
Cottonwoods & Aspen	25	0	7	0	1	0	3	14	0	0	0	0
Red alder	20	0	9	2	0	0	5	2	0	0	0	2
Timberland Oaks	195	15	102	15	0	0	12	38	1	7	3	2
Other Hardwoods	84	1	37	11	0	6	16	12	0	0	0	1
Woodland Species	0	0	0	0	0	0	0	0	0	0	0	0
Hardwood Subtotal	*324*	*16*	*165*	*36*	*1*	*6*	*36*	*83*	*1*	*9*	*9*	*5*
Unknown	*43*	*0*	*10*	*8*	*0*	*0*	*0*	*17*	*0*	*2*	*6*	*0*
Total	**1143**	**137**	**252**	**156**	**23**	**13**	**248**	**116**	**127**	**23**	**22**	**26**

APPENDIX C

Aerial Survey Tables: 1997, 1998 & 1999

The tables in this appendix contain summaries of data collected during aerial surveys of forested land in the summers of 1997, 1998 and 1999. The aerial survey begins in early July and usually ends in September, depending on weather and visibility conditions. It is timed to observe the maximum amount of damage in a two- to three-month period. Aerial survey observers have just a few seconds to recognize color differences between healthy and damaged trees of different species, correctly diagnose the cause of damage, estimate the intensity or extent of damage and record their observations on a 1:100,000 scale map. Numerous variables can affect the quality of the survey, such as visibility, similar damage symptoms on different hosts, and observer skill and training. In spite of these limitations, aerial surveys are a cost-effective way (less than 1 cent per acre) to rapidly estimate tree damage across large areas, and track changes in location and severity of damage from year to year. Information about the national aerial survey program can be found at this website: www.fs.fed.us/foresthealth/technology/program.html.

Table 1997a. Acres aerially surveyed for damage caused by insects, disease, and other agents in the West Coast Region in 1997.

		Acres Flown						
1997	Total Forested Acres	Forest Service	Other Federal	State	Private	Tribal	Total Flown	Total Not Flown
Alaska	129,000,000	5,623,000	5,549,000	7,895,000	1,365,000	4,175,000	24,607,000	104,393,000
Washington	20,500,000	7,992,586	1,509,219	2,130,778	6,764,153	1,560,167	19,956,903	543,097
Oregon	28,000,000	13,992,550	2,791,990	622,396	9,059,737	358,139	26,824,812	1,175,188
California	37,300,000	12,859,169	1,735,000	0	3,015,241	0	17,609,410	19,690,590
totals	214,800,000	40,467,305	11,585,209	10,648,174	20,204,131	6,093,306	88,998,125	125,801,875

Note: Total forested acres are from the following source: Forest Resources of the United States. 1992. USDA Forest Service. General Technical Report RM-234, 1993.

Note: Alaska does not differentiate between forested and non-forested acres flown because of presence of species of concern (such as willow) in areas defined as non-forested

Table 1997b. Acres of damage detected by aerial survey for tree species groups by damage category for West Coast states in 1997.

Alaska - 1997						
Damage Type	**Spruce/Hemlock**	**Cedar**	**Aspen/Birch/Cottonwood**	**Larch**	**Other**	**Total**
Mortality	572,687	0	0		2,209	574,896
Defoliation	100,915	0	13,569	267,861	3,502	385,847
Discoloration	13,724	0	266,465		0	280,189
Dieback	10	477,540	0		0	477,550
Topkill	1,162	0	0		0	1,162
Branch Breakage	0	0	0		0	0
Main Stem Broken/Uprooted	2,674	0	0		0	2,674
Total Acres	691,172	477,540	280,034	267,861	5,711	1,722,318

Note: Not all forested acres are flown in Alaska

Washington - 1997						
Damage Type	**W. Larch**	**Douglas-fir/True Fir**	**Pine**	**Spruce/Hemlock**	**Other**	**Total**
Mortality - Acres	0	44,204	83,351	4,579	3,283	135,417
Mortality - No. Trees	0	45,845	167,831	6,057		219,733
Defoliation - Acres	385,260	165,975	766	1,047	0	553,048
Discoloration - Acres	0	0	0	0	3,578	3,578
Dieback - Acres	0	0	0	22	2,189	2,211
Topkill - Acres	0	172	0	0	0	172
Topkill - No. Trees	0	80	0	0	0	80
Branch Breakage - Acres	0	0	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0	4,627	4,627
Total Acres	385,260	210,351	84,117	5,648	13,677	699,053
Total No. Trees	0	45,925	167,831	6,057	0	219,813

Oregon - 1997						
Damage Type	**Pines**	**Douglas-fir/True Fir**	**W. Larch**	**Port-Orford-Cedar**	**Other**	**Total**
Mortality - Acres	84,770	21,672	0	3,846	799	111,087
Mortality - No. Trees	181,257	18,681	0	4,354	0	204,292
Defoliation - Acres	25,341	16,693	8,240	0	1,036	51,310
Discoloration - Acres	0	0	0	0	0	0
Dieback - Acres	0	0	0	0	0	0
Topkill - Acres	0	11	0	0	0	11
Topkill - No. Trees	0	15	0	0	0	15
Branch Breakage - Acres	0	0	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0	0	0
Total Acres	110,111	38,376	8,240	3,846	1,835	162,408
Total No. Trees	181,257	18,696	0	4,354	0	204,307

California – 1997				
Damage Type	**Pines**	**Douglas-fir/True Fir**	**Hardwoods**	**Total**
Mortality - Acres	78,143	14,303	11,198	103,644
Defoliation - Acres	0	0	0	0
Discoloration - Acres	0	0	0	0
Dieback - Acres	0	0	0	0
Topkill - Acres	0	0	0	0
Branch Breakage - Acres	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0
Total Acres	78,143	14,303	11,198	103,644

Note: Not all forested acres are flown in California; only mortality was recorded in 1997.

Table 1997c. Acres (thousands) of defoliation detected by aerial survey in West Coast states from 1988 to 1997.

	Defoliation									
State	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Alaska	NA	208.5	175.9	199.2	483.2	438.0	466.4	466.8	921.0	385.8
Washington	291.7	378.2	359.9	1,050.2	1,345.1	366.0	133.0	182.4	188.7	553.0
Oregon	2,720.9	1,428.2	2,372.7	3,732.6	2,056.4	135.9	452.3	33.6	20.3	51.3
California	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
totals	3,012.6	2,014.9	2,908.5	4,982.0	3,884.7	939.9	1,051.8	682.8	1,130.0	990.2

Note: Not all forested lands are flown in Alaska and California. California did not record defoliation in 1997.

Table 1997d. Acres (thousands) of mortality and numbers of killed trees (thousands) detected by aerial survey in West Coast states from 1988 to 1997.

	Mortality									
State	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Alaska										
acres	NA	208.1	232.7	386.3	609.0	729.0	916.9	614.8	1,151.8	574.9
Washington										
acres	482.4	953.6	600.7	397.2	232.7	483.8	247.0	338.2	130.7	135.4
# trees killed	407.4	1,514.3	669.9	406.8	255.9	761.0	367.1	506.4	247.3	219.7
Oregon										
acres	1,686.7	3,256.4	983.5	832.3	1,024.4	1,048.4	590.7	865.1	510.2	111.5
# trees killed	4,603.2	3,399.0	564.9	907.9	1,210.0	916.6	510.9	992.1	1,264.4	204.8
California										
acres	NA	NA	NA	NA	NA	NA	809.3	592.3	139.6	103.6
total acres	2,169.1	4,418.1	1,816.9	1,615.8	1,866.1	2,261.3	2,563.9	2,410.4	1,932.2	925.5
total trees killed	5,010.6	4,913.3	1,234.8	1,314.7	1,465.9	1,677.6	878.0	1,498.5	1,511.7	424.5

Note: In Alaska and California, killed trees are not tallied and not all forested lands are flown.

Table 1998a. Acres aerially surveyed for damage caused by insects, disease, and other agents in the West Coast Region in 1998.

		Acres Flown						
1998	Total Forested Acres	Forest Service	Other Federal	State	Private	Tribal	Total Flown	Total Not Flown
Alaska	129,000,000	5,435,000	7,306,000	8,212,000	1,129,000	4,527,000	26,609,000	102,391,000
Washington	20,500,000	7,992,586	1,451,092	2,139,955	7,153,255	1,569,043	20,305,931	194,069
Oregon	28,000,000	13,992,550	2,804,035	630,885	10,388,216	358,139	28,173,825	0
California	37,300,000	10,489,150	1,735,000	0	3,015,241	171,779	15,411,170	21,888,830
totals	214,800,000	37,909,286	13,296,127	10,982,840	21,685,712	6,625,961	90,499,926	124,473,899

Note: Total forested acres are from the following source: Forest Resources of the United States. 1992. USDA Forest Service. General Technical Report RM-234, 1993.

Note: Alaska does not differentiate between forested and non-forested acres flown because of presence of species of concern (such as willow) in areas defined as non-forested

Table 1998b. Acres of damage detected by aerial survey for tree species groups by damage category for West Coast states in 1998.

Alaska - 1998						
Damage Type	**Spruce/Hemlock**	**Cedar**	**Aspen/Birch/Cottonwood**	**Larch**	**Other**	**Total**
Mortality	151,479	0	0	0	0	151,479
Defoliation	13,150	0	22,540	11,960	118,030	165,680
Discoloration	1,370	0	0	0	300	1,670
Dieback	0	479,082	0	0	0	479,082
Topkill	710	0	0	0	0	710
Branch Breakage	0	0	0	0	0	0
Main Stem Broken/Uprooted	20	0	0	0	0	20
Total Acres	166,729	479,082	22,540	267,861	118,330	1,054,542

Note: Not all forested acres are flown in Alaska

Washington - 1998						
Damage Type	**Douglas-fir/True Fir**	**Pine**	**Western Larch**	**Spruce/Hemlock**	**Other**	**Total**
Mortality - Acres	44,658	48,722	0	2,048	2,689	98,117
Mortality - No. Trees	44,257	100,524	0	1430	0	146,211
Defoliation - Acres	486,896	717	40,494	13,509	223	541,839
Discoloration - Acres	0	0	0	0	133	133
Dieback - Acres	2,052	632	0	0	4,961	7,645
Topkill - Acres	0	0	0	0	0	0
Topkill - No. Trees	0	0	0	0	0	0
Branch Breakage - Acres	0	0	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0	154	154
Total Acres	533,606	50,071	40,494	15,557	8,160	647,888
Total No. Trees	44,257	100,524	0	1,430	0	146,211

Oregon - 1998						
Damage Type	**Pines**	**Douglas-fir/True Fir**	**W. Larch**	**Spruce/Hemlock**	**Other**	**Total**
Mortality - Acres	69,141	28,864	0	1,120	1778	100,903
Mortality - No. Trees	239,220	34,816	0	1,393	1467	276,896
Defoliation - Acres	82,243	28,991	31,950	6,846	0	150,030
Discoloration - Acres	0	0	0	0	464	464
Dieback - Acres	32	614	0	0	0	646
Topkill - Acres	0	0	0	0	0	0
Topkill - No. Trees	0	0	0	0	0	0
Branch Breakage - Acres	0	0	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0	0	0
Total Acres	151,416	58,469	31,950	7,966	2,242	252,043
Total No. Trees	239,220	34,816	0	1,393	1,467	276,896

California – 1998				
Damage Type	**Pines**	**Douglas-fir/True Fir**	**Hardwoods**	**Total**
Mortality - Acres	58,021	26,553	0	84,574
Defoliation - Acres	0	0	0	193
Discoloration - Acres	0	0	0	0
Dieback - Acres	0	0	0	0
Topkill - Acres	0	0	0	0
Branch Breakage - Acres	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0
Total Acres	58,021	26,553	0	84,767

Note: Not all forested acres are flown in California; primarily mortality is recorded

Table 1998c. Acres (thousands) of defoliation detected by aerial survey in West Coast states from 1989 to 1998.

	Defoliation									
State	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Alaska	208.5	175.9	199.2	483.2	438.0	466.4	466.8	921.0	385.8	165.7
Washington	378.2	359.9	1,050.2	1,345.1	366.0	133.0	182.4	188.7	553.0	541.8
Oregon	1,428.2	2,372.7	3,732.6	2,056.4	135.9	452.3	33.6	20.3	51.3	150.0
California	NA	NA	NA	NA	NA	NA	NA	NA	NA	193.0
totals	2,014.9	2,908.5	4,982.0	3,884.7	939.9	1,051.8	682.8	1,130.0	990.2	857.5

Note: Not all forested lands are flown in Alaska and California.

Table 1998d. Acres (thousands) of mortality and numbers of killed trees (thousands) detected by aerial survey in West Coast states from 1989 to 1998.

	Mortality									
State	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Alaska										
acres	208.1	232.7	386.3	609.0	729.0	916.9	614.8	1,151.8	574.9	151.5
Washington										
acres	953.6	600.7	397.2	232.7	483.8	247.0	338.2	130.7	135.4	98.1
# trees killed	1,514.3	669.9	406.8	255.9	761.0	367.1	506.4	247.3	219.7	146.2
Oregon										
acres	3,256.4	983.5	832.3	1,024.4	1,048.4	590.7	865.1	510.2	111.5	100.9
# trees killed	3,399.0	564.9	907.9	1,210.0	916.6	510.9	992.1	1,264.4	204.8	276.9
California										
acres	NA	NA	NA	NA	NA	809.3	592.3	139.6	103.6	84.6
total acres	4,418.1	1,816.9	1,615.8	1,866.1	2,261.3	2,563.9	2,410.4	1,932.2	925.5	453.1
total trees killed	4,913.3	1,234.8	1,314.7	1,465.9	1,677.6	878.0	1,498.5	1,511.7	424.5	423.1

Note: In Alaska and California, killed trees are not tallied and not all forested lands are flown.

Table 1999a. Acres aerially surveyed for damage caused by insects, disease, and other agents in the West Coast Region in 1999.

		Acres Flown						
1999	Total Forested Acres	Forest Service	Other Federal	State	Private	Tribal	Total Flown	Total Not Flown
Alaska	129,000,000	5,737,080	10,301,070	7,882,934	2,143,918	5,281,379	31,346,385	97,653,615
Washington	20,983,173	7,992,586	1,607,770	2,149,022	7,596,349	1,590,023	20,935,750	47,423
Oregon	28,173,825	13,992,550	2,803,369	630,885	10,307,203	358,139	28,092,146	81,679
California	37,300,000	13,152,748	9,387,612	0	0	0	22,540,360	14,759,640
totals	215,456,998	40,874,964	24,099,821	10,662,841	20,047,470	7,229,541	102,914,641	112,542,357

Note: Total forested acres are from the following source: Forest Resources of the United States. 1992. USDA Forest Service. General Technical Report RM-234, 1993.

Note: Alaska does not differentiate between forested and non-forested acres flown because of presence of species of concern (such as willow) in areas defined as non-forested.

Table 1999b. Acres of damage detected by aerial survey for tree species groups by damage category for West Coast states in 1999.

Alaska - 1999						
Damage Type	**Spruce/Hemlock**	**Cedar**	**Aspen/Birch/Cottonwood**	**Larch**	**Other**	**Total**
Mortality	256,154	494,000	0	30,316	141,410	921,880
Defoliation	4,150	0	21,679	159,260	182,211	367,300
Discoloration	277	0	0	0	533	810
Dieback	0	0	0	0	0	0
Topkill	2,234	0	0	0	0	2,234
Branch Breakage	0	0	0	0	0	0
Main Stem Broken/Uprooted	0	0	0	0	0	0
Total Acres	262,815	494,000	21,679	189,576	324,154	1,292,224

Note: Not all forested acres are flown in Alaska

Washington - 1999						
Damage Type	**Douglas-fir/True Fir**	**Pine**	**Western Larch**	**Spruce/Hemlock**	**Other**	**Total**
Mortality - Acres	81,116	76,133	0	1,052	1,320	159,621
Mortality - No. Trees	126,128	333,526	0	1,289	785	461,728
Defoliation - Acres	189,957	3,099	2,048	320	1,433	196,857
Discoloration - Acres	0	0	0	0	711	711
Dieback - Acres	1,961	2,938		18	329	5,246
Topkill - Acres	0	0	0	0	0	0
Topkill - No. Trees	0	0	0	0	0	0
Branch Breakage - Acres	0	0	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0	810	810
Total Acres	273,034	82,170	2,048	1,390	4,603	363,245
Total No. Trees	126,128	333,526	0	1,289	785	461,728

Oregon - 1999						
Damage Type	**Pines**	**Douglas-fir/True Fir**	**Western Larch**	**Spruce/Hemlock**	**Other**	**Total**
Mortality - Acres	49,778	88,916	0	1,254	3,226	143,174
Mortality - No. Trees	95,975	137,548	0	480	4,435	238,438
Defoliation - Acres	17,255	47,263	15,721	201	39	80,479
Discoloration - Acres	0	0	0	0	33	33
Dieback - Acres	201	5,235	0	0	0	5,436
Topkill - Acres	0	0	0	0	0	0
Topkill - No. Trees	0	0	0	0	0	0
Branch Breakage - Acres	0	0	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	0	0	0	28	28
Total Acres	67,234	141,414	15,721	1,455	3,326	229,150
Total No. Trees	95,975	137,548	0	480	4,435	238,438

California – 1999				
Damage Type	**Pines**	**Douglas-fir/True Fir**	**Hardwoods**	**Total**
Mortality - Acres	17,844	15,256	0	33,100
Defoliation - Acres	0	76,451	0	76,451
Discoloration - Acres	0	0	0	0
Dieback - Acres	0	0	0	0
Topkill - Acres	0	0	0	0
Branch Breakage - Acres	0	0	0	0
Main Stem Broken/Uprooted - Acres	0	762	0	762
Total Acres	17,844	92,469	0	110,313

Note: Not all forested acres are flown in California.

Table 1999c. Acres (thousands) of defoliation detected by aerial survey in West Coast states from 1990 to 1999.

	Defoliation									
State	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Alaska	175.9	199.2	483.2	438.0	466.4	466.8	921.0	385.8	165.7	367.3
Washington	359.9	1,050.2	1,345.1	366.0	133.0	182.4	188.7	553.0	541.8	196.0
Oregon	2,372.7	3,732.6	2,056.4	135.9	452.3	33.6	20.3	51.3	150.0	80.5
California	NA	NA	NA	NA	NA	NA	NA	NA	.193	76.5
totals	2,908.5	4,982.0	3,884.7	939.9	1,051.8	682.8	1,130.0	990.2	857.7	720.2

Note: Not all forested lands are flown in Alaska and California.

Table 1999d. Acres (thousands) of mortality and numbers of killed trees (thousands) detected by aerial survey in West Coast states from 1990 to 1999.

	Mortality									
State	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Alaska										
acres	232.7	386.3	609.0	729.0	916.9	614.8	1,151.7	574.9	151.5	921.9
Washington										
acres	600.7	397.2	232.7	483.8	247.0	338.2	130.7	135.4	98.1	158.4
# trees killed	669.9	406.8	255.9	761.0	367.1	506.4	247.3	219.7	146.2	461.4
Oregon										
acres	983.5	832.3	1,024.4	1,048.4	590.7	865.1	510.2	111.5	100.9	142.9
# trees killed	564.9	907.9	1,210.0	916.6	510.9	992.1	1,264.4	204.8	276.9	238.2
California										
acres	NA	NA	NA	NA	809.3	592.3	139.6	103.6	84.6	33.1
total acres	1,816.9	1,615.8	1,866.1	2,261.3	2,563.9	2,410.4	1,932.2	925.5	453.1	1,256.3
total trees killed	1,234.8	1,314.7	1,465.9	1,677.6	878.0	1,498.5	1,511.7	424.5	423.1	699.6

Note: In Alaska and California, killed trees are not tallied and not all forested lands are flown.

APPENDIX D
Scientific & Common Names of Trees, Plants, Insects & Diseases

Common Name	Scientific Name
Trees	
Bishop pine	*Pinus attenuata*
Douglas-fir	*Pseudotsuga menziesii*
Eucalyptus	*Eucalyptus* spp.
Monterey pine	*Pinus radiata*
Port-Orford-cedar	*Chamaecyparis lawsoniana*
Spruce	*Picea* spp.
Sugar pine	*Pinus lambertiana*
Western hemlock	*Tsuga heterophylla*
Western white pine	*Pinus monticola*
Other Plants	
Banana poka	*Passiflora mollissima*
English holly	*Ilex aquifolium*
Miconia	*Miconia calvescens*
Pampas grass	*Cortaderia selloana*
Yellow starthistle	*Centaura solstitialis*
Insects	
Asian longhorned beetle	*Anoplophora glabripennis*
Balsam woolly adelgid	*Adelges picea*
Black twig borer	*Xylosandrus compactus*
Gypsy moth	*Lymantria dispar*
Spruce beetle	*Dendroctonus rufipennis*
Two-spotted leaf hopper	*Sophonia rufofascia*
Diseases	
Pitch canker	*Fusarium circinatum* (syn. *F. subglutinans* f. sp. *pini*)
Port-Orford-cedar root disease	*Phytophthora lateralis*
Swiss needle cast	*Phaeocrytopus gaumanii*
White pine blister rust	*Cronartium ribicola*
No common name	*Septoria passiflorae*

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COVER PHOTO: A healthy, ancient sequoia in the Sequoia National Forest, California. Photo by Mike McMurray, M.E.I. Productions, Bend, OR.

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